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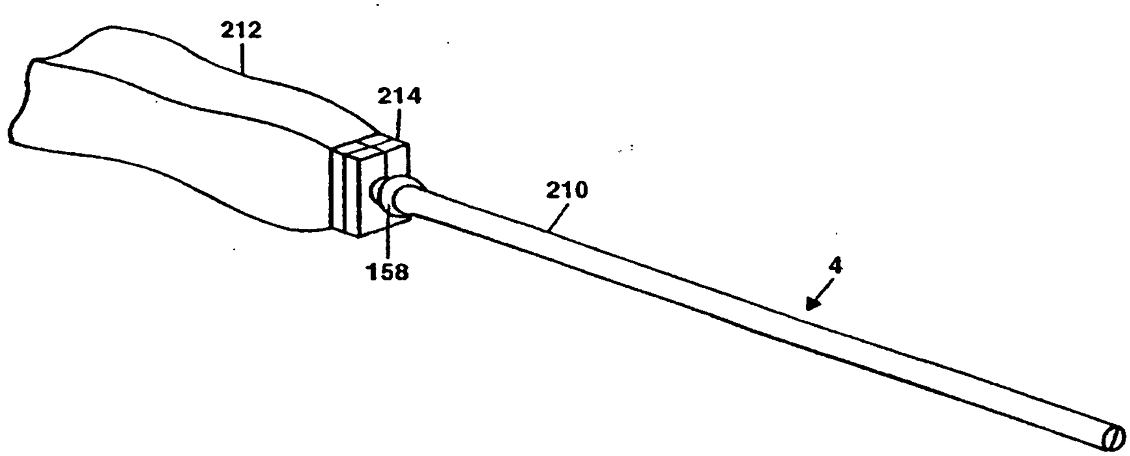
(54) Title: ENDOSCOPE SYSTEM



(57) Abstract: The present invention relates to an endoscope optic system having a base unit with a proximal end and a distal end, an optical system, an illumination device, an image relay device, an imaging device, and a sheath. The optical system can comprise distal optical elements and relay optics which can provide the formation of an image on the imaging device. The relay optical system a zoom mode for magnifying the object being viewed. In an embodiment, the optics, illumination device, the relay device and the sheath can be disposable after a single procedure which reduces the sterilization requirements and improves safety.

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ENDOSCOPE SYSTEM

RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 60/156,478, filed September 28, 1999, of U.S. Application No. 09/518,954, filed March 6, 2000, of U.S. Application No. 09/520,648, filed March 6, 2000, and of U.S. Application No. 09/521,044, filed March 6, 2000, the contents of the above applications being incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Endoscopes are devices which allow visual examination inside a hollow cavity. In the field of medicine, the use of endoscopes permits inspection of organs for the purpose of diagnosis, viewing of a surgical site, sampling tissue, or facilitating the safe manipulation of other surgical instruments. Laparoscopes are used particularly for examining organs in the abdominal area. Laparoscopes typically include a light pipe for illuminating the region to be viewed, at least one lens assembly for focusing and relaying the image of the illuminated object, and a housing for the entire assembly which is structured to minimize tissue damage during the surgical procedure. The light pipe can include a fiber optic element for illuminating the site. The laparoscope housing includes a distal section that can be inserted within a body cavity and a proximal section which can include a handle that a user grips to position the distal end near the surgical site.

Existing laparoscopes can include an imaging device such as a charge coupled device (CCD). This solid state imaging system is used to capture an image of an object being viewed and convey it to a viewing device, such as a monitor.

Currently, several problems exist with current laparoscope instruments. In laparoscope devices without a zoom system, in order for the viewer to obtain a closer view of an object, he has to adjust the position of the entire laparoscope manually. There is a risk of damaging or perforating soft tissues when the laparoscope is moved at a surgical site. Laparoscope devices containing zoom

lenses also have drawbacks. After zooming on an object to be viewed, the user must focus the lenses on the object to obtain a viewable image. A continuing need exists, therefore, for improvements in endoscopic design to provide safer, more economical, and effective systems for the examination of patients.

SUMMARY OF THE INVENTION

The invention relates to an endoscope system, and in a preferred embodiment, to a laparoscope having a tube with a proximal end and a distal end for insertion into body cavities or lumens for viewing of a site or region of interest. A preferred embodiment of the endoscope system can include an optical system, an illumination device, an imaging device, an image relay device, and a sheath. The optical system can comprise a distal lens system that can zoom in a range of magnifications between two imaging positions.

A preferred embodiment of the invention employs a base unit first sterile barrier and a second sterile barrier. The first sterile barrier or sheath can include a flexible handle portion that is draped over the handle which allows the user to insert his hand within the first barrier to hold and operate the handle. A probe portion of the first sterile barrier extends over the base unit probe and can be connected to the handle portion of the first barrier with a first sheath connector that attaches the first sheath or barrier to the base unit.

The first sheath connector can also be provided with a distal connector that attaches the first sheath to a second or primary sterile barrier. The second sterile barrier or sheath has a probe portion that extends over the first sheath probe position and includes a second sheath connector that connects to the distal connector on the first sheath.

In a preferred embodiment, the endoscope optical system includes a plurality of lens elements which affect performance and fabrication of the system in accordance with the present invention. Multiple lens elements yield less distortion of the image and have longer surface radii so that they are easier to fabricate. The distal end of the optical system can have a first lens and a second lens. The lenses form a virtual image of the object being viewed. Both the first and second lenses

can be mounted in a probe that is a reusable portion of the system, or alternatively, one or more optical elements can be integrated into the sheath, which is a disposable portion of the system. The optical system can also include, in a preferred embodiment, structures such as prisms, to change the angle of view of the endoscope. Viewing angles can be provided, preferably between 30 and 45 degrees, however other angles can be used.

In a preferred embodiment, the optics of the endoscope system can also include an image relay device positioned between the first set of distally mounted lens elements and a second set of lens elements positioned between the relay device and the image sensor. The relay couples an image to be viewed between the two sets of lenses. The zoom lens assembly can comprise a plurality of lenses. In a particular embodiment, there are four lenses in the zoom lens assembly. During zooming procedure, the first and third zoom assembly lenses remain stationary while the second and fourth zoom assembly lenses translate along the longitudinal axis of the optical system. Thus, the second and fourth zoom assembly lenses translate relative to the first and third zoom assembly lenses, respectively, to create an enlarged image of the object being viewed. The imaging device can also translate with the second and fourth zoom assembly lenses during a zooming procedure.

The zoom assembly lenses can be fabricated from a glass material. The zoom assembly lenses can be non-disposable, and reused after each procedure following sterilization. In another embodiment, the zoom assembly lenses can be manufactured from a plastic material. One of the plastic zoom assembly lens elements can be a diffractive element. In a preferred embodiment, the third relay lens element is a diffractive element. One or more of the zoom assembly lenses can be disposable with the sheath. Note that ground glass lenses in structures can be difficult to manufacture. Because the lenses of the present invention can be plastic and relatively inexpensive, the zoom assembly optics, illumination tube, and sheaths can be disposable after a single procedure and thereby reduce the sterilization needs for the system.

In a preferred embodiment, the illumination device is a plurality of optical fibers that extend in an annular ring around the optical system. Alternatively, the

illumination device is a plastic extruded tube which carries light to the distal end to facilitate viewing of the physiologic object or site.

In a preferred embodiment, the imaging device can be a solid state imaging sensor, such as a two dimensional charge coupled device (CCD) or CMOS imaging device. The imaging device can be positioned in the distal section of the endoscope system.

In a preferred embodiment, the endoscope system includes an image relay device such as a cylindrical tube or tunnel within the optical path that relays collimated light through a portion of the endoscope. The tunnel can be formed with an inner wall surface that absorbs light diverging from the optical path of the optical system and minimizes unwanted light and hard to image light, thus minimizing veiling glare. A high resolution optical image is formed at the plane of the imaging device. The tunnel reduces the manufacturing tolerances associated with optical alignment and optical fabrication. The walls of the tunnel are textured so as to disperse about 95% of the unwanted light. The length of the tunnel is a factor that determines proper illumination for the imaging device. The length of the tunnel also controls the depth of field of view for both wide angle and zoom operation.

The laparoscope can also include, in another embodiment, a sheath that can have a series of lenses, including one or more lenses of the zoom assembly optics. The laparoscope has a zoom control that actuates the zoom assembly. The zoom control can be mechanically operated, or in another embodiment, the zoom can be motorized. A finger operated switch on the handle can operate the motor or mechanically move the zoom assembly. Alternately, a foot switch can be used to move or operate the zoom assembly.

The invention further relates to a method of using an endoscope system. The method involves a sheath, optics and tunnel on a laparoscope, placing the laparoscope within a surgical area, adjusting a zoom control to view an object and removing the laparoscope from the surgical area. The sheath, the optics and relay can then be removed from the laparoscope and replaced with sterile elements. The method can then be repeated for a different patient while maintaining the sterility of the instrument.

The disposable sheaths used with the endoscope system can be replaced with disposable sheaths in a kit. Each kit can contain one or more first sheaths, one or more distal viewing or zero angle second sheaths and one or more angled viewing second sheaths. Different applications have replaced kits configured differently.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a preferred embodiment of the endoscope optic system with a sheath assembly in accordance with the present invention.

Figure 2 illustrates a preferred embodiment of distal optics and a relay device in an optical system.

Figure 3A illustrates the components of a laparoscope probe and sheath assembly.

Figure 3B illustrates the components of an alternate embodiment of a laparoscope probe and sheath assembly.

Figure 4 shows a preferred embodiment of an laparoscope optical system.

Figure 5 shows the optical system of Figure 4 positioned in a zoom configuration.

Figure 6A shows an embodiment for a second sterile barrier or sheath.

Figure 6B illustrates an embodiment for a first sterile barrier for a laparoscope.

Figure 6C shows an embodiment of a zoom control for a laparoscope.

Figure 7 shows a side view of an alternate embodiment of the sterile barrier of Figure 6A.

Figure 8 shows a top view of an alternate embodiment of the sterile barrier of Figure 6A.

Figure 9 illustrates a side view of an alternate embodiment of the sterile barrier of Figure 6A.

Figure 10 illustrates a top view of an alternate embodiment of the sterile barrier of Figure 6A.

Figure 11 shows an embodiment of a zoom control for a laparoscope.

Figures 12A and 12 B shows alternate embodiments of the zoom control of Figure 11.

Figure 13A illustrates a front view of a laparoscope showing an embodiment of a zoom control.

Figure 13B shows a cross-sectional view of the laparoscope showing a zoom control.

Figure 14 shows an embodiment of a handle of a laparoscope or endoscope.

Figure 15 illustrates an alternate embodiment of the handle of Figure 14.

Figure 16 illustrates an alternate embodiment of the handle of Figure 14.

Figure 17 illustrates an alternate embodiment of the handle of Figure 14.

Figure 18 shows an embodiment of a zoom assembly for a laparoscope.

Figure 19 illustrates an adaptor for a laparoscope.

Figure 20 illustrates a detailed view of the adaptor shown in Figure 19.

Figure 21 shows an alternate embodiment of the adaptor shown in Figures 20A and 20B.

Figure 22A illustrates a 0° angle sheath for an endoscope.

Figure 22B illustrates light entering the 0° angle sheath at Figure 22A.

Figure 22C shows an enlarged cross-sectional view of a 0° sheath.

Figure 22D shows an alternate embodiment of the 0° sheath shown in Figure 22C.

Figure 22E shows a 30° angle sheath for an endoscope.

Figure 22F illustrates light entering the 30° angle of Figure 22E.

Figure 22G shows a 30° angle sheath attached to an endoscope.

Figure 22H illustrates an enlarged cross-sectional view of a 30° angle sheath.

Figure 22I and 22J shows an alternate embodiment of a 30° angle sheath.

Figures 22K and 22L show another alternate embodiment of a 30° sheath.

Figures 22M and 22N show another alternate embodiment of a 30° sheath.

Figure 23 illustrates a view of an embodiment of a sheath having an adaptor housing mounted on its distal end.

Figure 24 shows an alternate embodiment of the adaptor housing and sheath in Figure 23.

Figure 25A illustrates a cross sectional view of an embodiment of an endoscope.

Figure 25B shows a cross-sectional view of a first sterile barrier for an endoscope.

Figure 26 shows the lenses of an endoscope as rectangularly shaped.

DETAILED DESCRIPTION OF THE INVENTION

A preferred embodiment of the endoscope system in accordance with the present invention is illustrated in Figure 1. A laparoscope and sheath assembly 2 can be used, for example, in minimally invasive surgical procedures involving examination of the abdomen and abdominal organs. The assembly 2 contains both a laparoscope base unit 6 and a sheath or first sterile barrier 4. In a preferred embodiment, the laparoscope 6 is reusable and the sterile barrier 4 is disposable. The laparoscope 6 can also have a second sterile barrier 82 which attaches to the laparoscope 6 over the laparoscope 6 and the first sterile barrier 4. The second sterile barrier 82 is the second sheath that attaches to the laparoscope 6 after the attachment of the first sterile barrier 4 to the laparoscope 6. Because the first sterile barrier 4 attaches to the laparoscope 6 before the attachment of the second sterile barrier 82, the second sterile barrier 82 contacts biological tissue when the laparoscope 6 is inserted into a surgical site.

The laparoscope 6, in a preferred embodiment, can contain a zoom assembly which allows a user to obtain an enlarged view of an object during a laparoscopic surgical procedure without having to adjust the position of the laparoscope inside the patient. The laparoscope 6 can have a light source connector, an electrical source connector, an illumination coupling device, an interlocking mechanism and a zoom control. The laparoscope 6 can have a distal laparoscope end 20 and a proximal

laparoscope end 22, as shown in Figure 1. The laparoscope can also have an optical system 100 which can include distal optics 102, an image relay device 120, zoom assembly optics 104 and an imaging device 106. The laparoscope 6 can also include a handle 10 and a probe 14. In a preferred embodiment, the probe 14 is hollow and can contain an illumination device, an imaging device, an image relay device and zoom assembly optics. Various features of a zoom laparoscope can be found in the application by John L. Bala and Paul Remijan, filed on September 9, 1998 having U.S. Serial No. 09/150,134, the entire contents of this application being incorporated herein by reference.

The probe 14 of the laparoscope base unit allows viewing of the inside of a physiologic cavity. The probe 14, in a preferred embodiment, is composed of stainless steel. In an alternate embodiment, the probe 14 is composed of any biologically compatible and sterilizable material. The probe 14 is elongated, having a diameter, for example, in the range between 6.8 mm and 7.2 mm and is between 350 mm and 420 mm in length. In one example of a preferred embodiment, the length of the probe 14 can be 390 mm.

In one embodiment, the laparoscope base unit 6 contains both a light source connector to provide the laparoscope assembly 2 with light from an outside source and an electrical connector which provides the laparoscope assembly 2 with power from an external source. The light source connector can be located at the proximal end of the laparoscope 6. In a preferred embodiment, the light source connector is mounted to a rear face of the laparoscope 6 and is parallel to the probe 14 to allow for ease of handling the laparoscope assembly 2. In an alternative embodiment, the laparoscope assembly 2 can contain an internal lighting and power source. The illumination device of the laparoscope base unit provides light to the distal end of the laparoscope and sheath assembly 2. The illumination device can be coupled to the light source connector at the proximal end of the laparoscope and sheath assembly 2. In a preferred embodiment, the illumination device is a fiber optic annulus.

Figure 2 illustrates an embodiment of the image relay optics 102 and image relay 120 of the optical system 100. In a preferred embodiment, the image relay

optics 102 and image relay 120 are located at the distal end 20. In another preferred embodiment, the image relay optics 102 have a first lens 108 and a second lens 110.

In one embodiment, the image relay optics 102 is a negative lens which forms a virtual image of the object being viewed. The greater the amount of negative power, the greater is the increase in the field of view, the distortion and the ratio of the focal length of the lens system to the effective diameter of its aperture. The number of elements of the image relay optics affect performance and manufacturability of the system. Multiple elements of the image relay optics 102 create less distortion of the image being viewed. Further, multiple elements have a longer surface radii than single elements and are easier to fabricate. In a preferred embodiment, the first 108 and second 110 image relay lenses are fabricated from a plastic material. During a zooming procedure, the image relay optics 102 remain stationary.

The image relay 120 has a distal end 124 and a proximal end 126 and functions to minimize or absorb unwanted light and hard to image light to prevent veiling glare. The image relay 120 provides high resolution of an optical image at the plane of the imaging device, removes intermediate image planes and reduces the tolerances needed for optical alignment and optical fabrication. In a preferred embodiment, the image relay 120 is a cylindrical pipe having a highly absorbing inner wall. The image relay 120 has a tunnel wall 122 that can absorb light diverging from the distal optics 102. In a preferred embodiment, the tunnel wall 122 has a rough wall surface. The rough wall surface can disperse up to about 95% or more of unwanted light. The image relay 120 can also have an aperture stop at its distal end nearest the distal optics 102 which can influence the F number of the optic system 100. The image relay 120 can be manufactured as a stress free glass tunnel or a stress free plastic tunnel. In one embodiment, the distal end 124 of the plastic tunnel is molded as an element of the distal optics 102. In an alternate embodiment, the proximal end 126 of the plastic tunnel is molded as an element of zoom assembly optics 104, housed in the laparoscope. The length of the image relay 120 is an additional factor that determines the change in F number of the system. In particular, the length of the image relay 120 determines the change in F number

associated with full zoom and wide angle operations. The length of the image relay 120 can range from 10 to 40 mm. In a preferred embodiment, the length of the tunnel is 24.6 mm. The length of the image relay 120 affects proper illumination of an imaging device, controls depth of field of view for wide angle and zoom operation, increases F number for adequate depth of field of view for zoom operation and allows transition from wide field to full zoom without the need to refocus the system. The image relay 120 can also be disposable.

Figure 3A illustrates the components of an embodiment of a laparoscope and sheath assembly 290. The assembly 290 can have a slide control sleeve 300, an imaging device position sheath 302 and an imaging device 304. In a preferred embodiment, the imaging device 304 is a charge coupled device or other pixilated imaging sensor. The assembly 290 can have zoom assembly optics which can include a first lens element 306, a second lens element 308, a third lens element 310 and a fourth lens element 312. The assembly can have image distal optics which can include a first lens 314 and a second lens 316. The third lens element 310 can be contained in a mount 318. A clamp 320 can also hold the third lens element 310. The second lens element 308 can also be mounted inside a clamp 322. The fourth lens element 312 can also be mounted inside a mount 324. The fourth lens element 312 can also include a clamp 326.

The assembly 290, in this embodiment, can also have an image relay 328. The imaging device 304 can have an imaging device sleeve 332 and a extension sleeve 330. The imaging device sleeve 332 can also have a first slide sleeve 334 and a second slide sleeve 336.

The assembly 290 can also have a sleeve 344 which has an inner sleeve 338, a fiber bundle 340, which can carry light to an object, and an outer sleeve 342. The assembly 290 can also have a primary sheath 346. The primary sheath 346 can have an adaptor 348 and an optical surface 350. The assembly 290 can also have a rotating outer sheath 352. The rotating outer sheath 352 can have a zero view adaptor 354 and the second lens 316.

Figure 3B illustrates the components of an alternate embodiment of a laparoscope and sheath assembly 500. The assembly 500 can have a slide control

sleeve 532, an imaging device position sheath 534 and an imaging device 504. The assembly 500 can have zoom assembly optics which can include a first lens element 506, a second lens element 502, a third lens element 508 and a fourth lens element 510. The assembly can have image distal optics which can include a first lens 512 and a second lens 514. The first lens element 506 can be secured in a clamp 552. The second lens element 502 can also be mounted inside a clamp 530. The third lens element 508 can be contained in a clamp 528, the clamp 528 and lens 508 assembly contained within a mount 526. The fourth lens element 510 can also be secured within a clamp 525 and contained within a mount 522.

The imaging device 504 can have an imaging device sleeve 516. The imaging device sleeve 516 can have a first slide sleeve 518 and a second slide sleeve 520. In a preferred embodiment, the imaging device 504 is a charge coupled device or other pixilated imaging sensor.

The assembly 500 can also have an inner sleeve 538 and an outer sleeve 542 which can enclose a fiber bundle. The assembly 500 can also have a primary sheath 544 which includes an adaptor 540 which can accept a mating portion from a primary sterile barrier or from a first sterile barrier. The primary sheath 544 can also have an optical surface 536. The assembly 500 can also have a rotating outer sheath 548. The rotating outer sheath 548 can have a zero view adaptor 546. The assembly 500 can also have an ACMI connector 556 for electrical connection to a power source and a connector nut 558 for attachment of the connector 556 to the assembly.

Figures 4 and 5 illustrate an embodiment of an optical system 100 of a laparoscope 6 in a standard (1X) and a zoom (3X) configuration, respectively. The optic system 100 can have image relay optics 102, zoom assembly optics 104 and an imaging device 106. In a preferred embodiment, the optical system is located within the laparoscope 6. The optical system 100 can also have an image relay 120 located between the distal optics 102 and the zoom assembly optics 104. The optical elements of the optic system can have a diameter of 7 mm.

The zoom assembly optics 104 can have a first zoom assembly lens 112, a second zoom assembly lens 114, a third zoom assembly lens 116 and a fourth zoom assembly lens 118. The zoom assembly optics 104 form a high resolution, real

image on the imaging device 106 from the virtual image created by the distal optics 102. The zoom assembly optics 104 act on semi-collimated light passing through the tunnel 120. In a preferred embodiment, during a zooming procedure, the first 112 and third 116 zoom assembly lenses remain stationary while the second 114 and fourth 118 zoom assembly lenses translate along the longitudinal axis a of the optic system 100. Figure 4 shows how, during a zooming procedure, the second 114 and fourth 118 zoom assembly lenses translate away from the first 112 and third 116 zoom assembly lenses, respectively, to create an enlarged image of an object being viewed. The zoom assembly optics 104 can create an image magnification of up to three times (3x) the size of the object being viewed. In a preferred embodiment, the zoom assembly optics 104 are fabricated from a glass material. The zoom assembly lenses 104 can be non-disposable, that are reused after each procedure following sterilization. In another embodiment, the zoom assembly lenses 104 can also be manufactured from a plastic material. One of the plastic zoom assembly lens elements 112, 114, 116, 118, can be a diffractive element. In a preferred embodiment, the third zoom assembly lens element 116 is a diffractive element. The zoom assembly optics 104 can be disposable with the distal optics 102.

The lens spacings for the zoom assembly lenses 104 can vary when the lenses are in a standard (1X) or a zoom (3X) configuration. The fourth zoom assembly lens 118 can be spaced 3 mm (0.156 inches) from the imaging device 106 in either a standard or a zoom configuration. The fourth zoom assembly lens 118 can be spaced 12.4 mm (0.488 inches) from the third zoom assembly lens 116 in a standard configuration and 20.7 mm (0.827 inches) from the third zoom lens 116 in a zoom configuration. The second zoom assembly lens 114 can abut the first zoom assembly 112 and can be spaced at a distance of 8.9 mm (0.125 inches) from the third zoom assembly lens 116 in a standard configuration. In a zoom configuration, the second zoom assembly lens 114 can abut the third zoom assembly lens 116 and be spaced 8.6 mm (0.137 inches) from the first zoom assembly lens 112.

During a zooming procedure, the imaging device 106, fourth lens 118 and second lens 114 can travel a distance between 8.1 and 8.9 mm. In a preferred

embodiment, these elements 106, 118, 114 travel a total of 8.3 mm during a zooming procedure.

The imaging device 106, in a preferred embodiment, can be a solid state imaging sensor, such as a charge coupled device (CCD) or a two dimensional CMOS imaging device. The imaging device 106 can be located in the distal section of the endoscope base unit 6. The imaging device 106 can be connected to an electrical source connector. The imaging device 106 can be a 1/4 inch CCD camera. The imaging device 106 can also have a focus adjustment but is preferably provided with a fixed focus without need of refocusing during use. The CCD camera has a resolution of at least 9 microns and provides high resolution visual detail of the surgical area being examined. During a zooming procedure, the imaging device 106 translates along the longitudinal axis a of the optic system 100. Figures 4 and 5 show how, during a zooming procedure, the imaging device 106 translates away from the first 112 and third 116 zoom assembly lenses and in conjunction with the second 114 and fourth lens 118 zoom assembly elements. The distance between the imaging device 106 and the fourth zoom assembly lens 118 can remain constant during the zooming procedure. The imaging device 106 can create additional magnification of an object being imaged. The imaging device 106 can increase the magnification of an object up to two times (2x). In an alternate embodiment, the imaging device 106 can be disposable with the image relay 102 and the zoom assembly optics 104.

The focus of the optics 104 of the endoscope 6, in one embodiment, does not have to be adjusted either during a zooming procedure or during manual adjustment or the endoscope relative to an object being imaged. The focus of the optics 104 in the endoscope can be pre-set by the manufacturer without need for adjustment by the user or need for adjustment prior to or after focusing.

The focus of the optics 104 of the endoscope 6 can be adjusted. For endoscopes in general, the image distance of an object is effectively the distance from the end of the endoscope to the object itself. In the general case, endoscopes have an entrance pupil near the distal end tip which allows the image distance to be measured from the distal end tip of the endoscope. As shown in Figure 2, the

entrance pupil 119 is not located at the distal end 20 of the endoscope 6. The image distance for the endoscope 6 will not be the distance from the distal end 20 to the object being imaged. Positioning of the entrance pupil 119 of the endoscope 6 away from the distal end 20 can increase the depth of field of view for the object being imaged. Focusing of the optics 104 of the endoscope 6 adjust the field of view for the object being imaged.

In another embodiment, the endoscope 6 includes a focus mechanism for the optics 104. The focus mechanism can adjust the positioning of the imaging device 106 to provide for reception of a clear image. Preferably, the focusing mechanism is engaged when the optics 104 have been moved to a zoom configuration. The focusing mechanism can be engaged after the endoscope 6 has moved closer to an object.

Figures 6A-6C collectively show an embodiment of a laparoscope and sheath assembly 2. In a preferred embodiment, the assembly 2 includes a laparoscope base unit 6, a second sterile barrier 82, and a first sterile barrier 4.

Figure 6A illustrates a preferred embodiment for the sheath second sterile barrier 82. In this embodiment, the sterile barrier 82 has a barrier attachment mechanism 150, a rotational mechanism 152, a sheath 28 and a rigid tube 26. The barrier attachment mechanism 150 allows a user to attach the sterile barrier 82 to a first sterile barrier 4. The rotational mechanism 152 can be made from a plastic or stainless steel component. In one embodiment, the barrier attachment mechanism 150 has a plurality of buttons 154. In this embodiment, to attach the sterile barrier 4 to the laparoscope 6, a user can compress the plurality of buttons 154 toward a central axis 156, place the sterile barrier 82 onto the first sterile barrier 4 and release the buttons 154, thereby securing the second sterile barrier 82 to the first sterile barrier 4. The sheath 28 of the second sterile barrier 82 can be made from plastic, such as PVC or PET. The second sterile barrier 82, in one embodiment, can have no mirror. The barrier 82 can optionally include a micro-switch activation to flip an image automatically.

Figure 6B shows an embodiment of a first sterile barrier 4. The sterile barrier 4 can slide over the laparoscope 6. In one embodiment, the first sterile

barrier 4 allows a user to change second sterile barriers 82, from a straight view to a 30 degree view, for example, while maintaining the sterility of the laparoscope 6.

The first sterile barrier 4 of Figure 6B maintains the sterility of the laparoscope 6 during a surgical procedure. The first sterile barrier 4 allows a user to replace the second sterile barrier 82 on the laparoscope 6 without breaking the sterile condition of the laparoscope 6. The first sterile barrier 4 can have a flexible sleeve 212, a sheath 210 and a clip 214. In a preferred embodiment, the flexible sleeve 212, sheath 210 and clip 214 are disposable. The sheath 210 can cover the probe 14 while the flexible sleeve 212 can cover a handle of the laparoscope 6. The clip 214 can connect the first sterile barrier 4 to the laparoscope 6.

The first sterile barrier 4 can have a sheath 210, a flexible sleeve 212 and a sheath connector or clip 214. The sheath 210 can fit around the probe 14 of the laparoscope 6. The flexible sleeve 212 can fit around the handle 10 of the laparoscope 6. The clip 214 can secure the first sterile barrier 4 to the laparoscope 6. The first sterile barrier 4 can be made of a flexible material. The barrier 4 can be made from a plastic or PVC, for example.

The components of Figures 6A and 6B can be provided in a replacement kit along with the angled viewing sheath described in detail herein.

Shown in Figure 6C is a base unit 6 including a probe 14, a handle 10, zoom control 174 and base unit sheath connector 175. In a preferred embodiment, the laparoscope 6 of Figure 6C is reusable. The laparoscope 6 can house image relay lenses, an image relay, zoom assembly lenses, a zoom assembly and an imaging device. Figure 7 and 8 illustrate an embodiment for the attachment of the laparoscope 6, first barrier 4 and second barrier 82. In this embodiment, the second barrier attachment mechanism 150 comprises a second sheath connector or clip 160 formed integral with the rotational mechanism 152. In this embodiment, first barrier 4 has a first barrier attachment mechanism 158 which engages the clip 160. To attach the second sterile barrier 82 in this embodiment, a user can depress the first barrier attachment mechanism or connector 158, place the second sterile barrier 82 onto the first barrier 4 and release the first barrier attachment mechanism 158, thereby securing the second sterile barrier 82 to the first barrier 4. The first barrier 4

can attach to the laparoscope 6 by a clip 214. The clip 214 can connect to a laparoscope attachment mechanism 153 to secure the first sterile barrier 4 to the laparoscope 6.

Figures 9 and 10 illustrate another alternate embodiment for the attachment of the laparoscope 6, first barrier 4 and second barrier 82. In this embodiment, the second barrier attachment mechanism 150 is a plurality of levers 162 which connect with a plurality of mating portions 164 on the first barrier 4. In this embodiment, to attach the second sterile barrier 82 to the first sterile barrier 4, a user can place the second sterile barrier 82 onto the first sterile barrier 4. The user can then engage the levers 162 of the barrier 82 with the mating portions 164 of the first sterile barrier 4 to secure the second sheath or barrier 82 to the first sterile barrier 4. The first barrier 4 can attach to the laparoscope 6 by a clip 214. The clip 214 can connect to a laparoscope attachment mechanism 153 to secure the first sterile barrier 4 to the laparoscope 6.

Alternately, the first barrier 4 can attach to the laparoscope 6 by a twist lock mechanism. The laparoscope 6 can include a mating portion while the first barrier 4 can include a distal cavity portion. The first barrier 4 can be placed over the laparoscope 6 and the mating portion of the laparoscope can join with the distal cavity portion of the first barrier 4. Once the mating portion of the laparoscope has become aligned within the distal cavity portion of the first barrier 4, the first barrier 4 can be rotated about a central axis 156. The mating portion can travel within an aperture in the distal cavity portion during rotation. Such rotational motion can lock the first barrier 4 onto the laparoscope 6. The twist lock mechanism attaches the first barrier 4 onto the laparoscope 6 to ensure the security of the first barrier 4 during a surgical procedure.

When a user has engaged the second sterile barrier 82 with the first sterile barrier 4, the second sterile barrier 82 can rotate about a central axis 156. The connection between the second sterile barrier 82 and the first sterile barrier 4 allows rotation of the second sterile barrier 82 while maintaining the second sterile barrier 82 securely on the endoscope 6. The rotation of the second sterile barrier 82 allows the user to change the view angle of an area being observed. In a preferred

embodiment, the sterile barrier can rotate $^{+}/-135$ degrees from a zero degree position. Therefore, the sterile barrier 82 has a total rotatability of 270 degrees. In another preferred embodiment, the rotational mechanism 152 has a detent 159, shown in Figure 7. The detent 159 allows the rotational mechanism 152 to maintain its position as it is rotated about a central axis 156.

The laparoscope and sheath assembly 2 can have a handle 10, an embodiment of which is shown in Figures 6C, 11, 12A and 12B. The handle 10 can have an illumination connector 170, an imaging device connector 172 and a zoom control 174. The handle 10 can also have a laparoscope attachment mechanism 153. The handle 10 can be made from aluminum. In one embodiment, the handle 10 is made from hard block anodized aluminum. In an alternate embodiment, the handle 10 is made from a solid block of aluminum. Aluminum allows the handle to be steam-sterilized. In another embodiment, the aluminum handle is coupled to a handle cover which can be made from PVC or plastic, for example.

The handle 10 of the laparoscope base unit 6 can contain a zoom control 174. The zoom control 174 allows the user to adjust the position of the slide section 44 which is connected to the second zoom assembly lens element 114 and the fourth zoom assembly lens element 116, thus allowing the user to adjust the image of an object being viewed. The zoom control 174 also controls the motion of the imaging device 106. As the zoom control 174 adjusts the position of the second 114 and fourth 115 lens elements, it translates the imaging device along the long axis α. In one embodiment, the zoom control 174 is located at the proximal end of the laparoscope base unit 6 to allow easy access during a surgical procedure. In a preferred embodiment, the zoom control 174 is operated manually as a sliding mechanism. The zoom control 174 has a range of motion sufficient to allow magnification and demagnification of an object being viewed. In an alternate embodiment, a rotating mechanism can be used. In another embodiment, a motorized mechanism can function as the zoom control 174.

In a preferred embodiment, the zoom control 174 has a zoom lock. As a user increases or decreases the zoom on an image being viewed, the user can lock the position at the zoom control 174. In this embodiment, the zoom control can be

detented to lock the control 174, and also the zoom assembly, into a desired position. To unlock the zoom control 174, the user would depress the zoom control 174 into the handle 10 thereby releasing the zoom control 174 and allowing for the motion of the zoom assembly.

Figures 6C, 11, 12A and 12B show embodiments of a zoom control 174. Figure 11 shows a handle 10 having a sliding zoom lever 176. Figure 12B shows a handle 10 having a switch-type lever 179. Figure 12A shows a handle 10 having a rotational zoom lever 178. In either embodiment, the zoom control 174 can adjust the positioning of the zoom assembly. During the zooming procedure, a user can move the zoom control 174 toward the illumination connector 170 and imaging device connector 172. This motion can increase the magnification of an object being imaged. The user can also move the zoom control 174 away from the illumination connector 170 and imaging device connector 172. This motion can decrease the magnification of an object being imaged.

Figures 13A and 13B illustrate font and side cross-sectional views, respectively, of a laparoscope 6 and show the zoom control 174 and an embodiment of a zoom mechanism 166. The zoom mechanism 166 connects the zoom control 174 to the slide section 44 of the zoom assembly 40. The zoom mechanism 166 can be attached to the slide section 44 of the zoom assembly 40 by a yoke element 167. Pushing on zoom control 174 creates a sliding movement of the zoom mechanism 166 which is translated to the slide section 44 by the yoke element 167. Such motion can adjust the zooming of the endoscope optics. Figure 13B also shows an illumination bundle 177 attached to the illumination connector 170. The illumination bundle 177 transfers light from a light source attached to the illumination connector 170 to an object being imaged.

Figures 14 through 17 illustrate embodiments for a handle 10 of a laparoscope 6. The handle 10 can have a plurality of designs. The handle 10 can be tapered 196 along a vertical axis 200, tapered 184 along a horizontal axis 202, grip shaped 190 or contoured 192. In these embodiments, the shape of the handle 10 allows for the ease of gripping and maneuvering the laparoscope 6.

Figures 14 through 17 illustrate different embodiments for a sterile barrier attachment mechanism 158. In one embodiment, the attachment mechanism 158 is a top-bottom mounted button 180. In another embodiment, the attachment mechanism 158 is a side-side mounted button 186. In either embodiment, to release a second sterile barrier 82 from the first sterile barrier 4, the buttons 180, 186 must be depressed toward the handle 10 to disengage the second sterile barrier 82 from the attachment mechanism 158.

Figures 14 through 17 also illustrate various embodiments for the rotational mechanism 152 of the second sterile barrier 82. In one embodiment, the rotational mechanism 152 is star shaped 182. The rotational mechanism 152 can also be lever-shaped 188 or star-and-ball shaped 194. In these embodiments, the shape of the rotational mechanism 152 allows a user to have a firm contact with the mechanism 152 and allows for ease of rotation of the mechanism 152.

Figure 18 shows an embodiment of a zoom assembly 40. In a preferred embodiment, the probe 14 includes a zoom assembly 40 which includes a fixed section 42 and a slide section 44. The fixed section 42 and slide section 44 can be slidably connected at a distal end of the laparoscope 6. In a preferred embodiment, the first zoom assembly lens 112 and the third zoom assembly lens 116 are mounted to the fixed section 42 of the laparoscope 2 while the second zoom assembly lens 114 and the fourth zoom assembly lens 118 are mounted to the slide section 44. Relative motion between the fixed 42 and slide 44 sections will change the position of the optics 104 inside the probe 14 and increase or decrease the magnification of an object being imaged. The imaging device 106 can also be attached to the slide section 44. Motion of the slide section can change the position of the second zoom assembly lens 114, the fourth zoom assembly lens 118 and the imaging device 106 relative to the first zoom assembly lens 112 and the third zoom assembly lens 116 during a zooming procedure.

To zoom an image of an object, a user would pull the slide section 44 of the laparoscope 6 away from the fixed section 42 of the laparoscope 6 using a zoom control. This motion causes the second lens element 114 and fourth lens element 118 to translate away from the first lens element 112 and the third lens element 116,

respectively. This can increase the magnification of the image being viewed. To reduce the magnification, the process can be reversed. To reduce the image of an object, a user would push the slide section 44 of the laparoscope 6 toward the fixed section 42 of the laparoscope.

The laparoscope and sheath assembly 2 can also have an illumination device. The illumination device can be fiber optics mounted around the probe 14 and can carry light to an object being imaged. In a preferred embodiment, the distal optics 102 are integrated with the illumination device.

Figure 19 shows an embodiment for the laparoscope and sheath assembly 2 wherein the assembly 2 has an adaptor or a prism system 50. The function of the prism system 50 can be wavelength dependent. The adaptor 50, in a preferred embodiment, can deflect both the image of an object being viewed and the illumination provided for the image. In a preferred embodiment, the adaptor 50 has a prism 56 used to deflect the image and illumination. The prism 56 can have a prism face 58 which is angled between 22.5 and 45 degrees relative to a longitudinal axis 60 of the assembly 6. In a preferred embodiment, the prism face 58 is angled at 30 degrees relative to the longitudinal axis 60. In a preferred embodiment, the prism 56 is manufactured from a plastic material.

When rotated about the longitudinal axis 60, the prism 56 provides the user with a 360 degree view of the surgical area being examined. In one embodiment, the user can rotate the laparoscope and sheath assembly 2 manually to obtain the 360 degree view. A rotational adjustment, however, can be used to rotate the adaptor 50 about the axis 60. The rotational adjustment can be located at a proximal end of the adaptor 50 and, in a preferred embodiment, the rotational adjustment is positioned so as to allow the user easy access, by means of the user's thumb or fingers, when operated using a one-handed method.

Figure 20 shows a detailed view of an embodiment for the adaptor or prism system 50. In this embodiment, the adaptor 50 carries a plurality of lenses 62 mounted adjacent to the prism 56. In a preferred embodiment, the adaptor 50 carries a first prism lens 64 and a second prism lens 66. The first prism lens 64 can have a first lens cylinder surface 68 and a first lens spherical surface 70. The second prism

lens 66 can have a second lens cylinder surface 72 and a second lens spherical surface 74. In a preferred embodiment, the spherical surfaces 70, 74 are rotationally symmetric.

Figure 21 shows an alternate embodiment of the adaptor or prism system 50. In this embodiment, the plurality of lenses 62 mounted adjacent to the prism 56 includes a first lens 76 and a second lens 78.

In one embodiment of a sheath for an endoscope 6, shown in Figure 22A, there can be a relatively large air gap 402 in the tunnel 120 between image relay optics 102 and the system aperture stop 406. The optics 104 for the endoscope 6 can have a diameter of 6 mm or less. The aperture stop 406 can be made from a glass material, such as BK7, for example, or can be made from plastic. The aperture stop 406 can be formed as part of a sterile barrier placed on the endoscope 6 or alternately the aperture stop can be formed as part of the endoscope 6. The air gap 402 can be traversed by minimally divergent light beams that pass through the system aperture stop 406. Figure 22B illustrates light 408 entering the endoscope 6. Light entering the image relay optics 102 at a 30 degree angle with respect to the scope axis can traverse the air gap 402 at an angle of only 7.5 degrees with respect to the scope axis 420.

Figure 22C illustrates a 0° angle sheath or adaptor 400 for an endoscope 6. The 0° sheath 400 can act as a second sterile barrier 82 for an endoscope 6. The adaptor 400 includes relay lenses 102, the air gap 402 within the tunnel 120 and optical elements 446. The optical elements 446 provide light that travels from a light source, through the endoscope 6 and to an object being imaged. The optical elements 446 can be made from a plastic, such as acrylic or polycarbonate to allow the passage at light. The adaptor 400 can include a mating portion 448 that interconnects with a distal cavity on the endoscope 6 or on a first sterile barrier 4.

Figure 22D illustrates an alternate embodiment of the 0° angle sheath 400. In this embodiment there is no optical element as described above. The sheath 400 can be made from PET or polyester. To create the sheath 400, the end of the sheath material 464 can be heated and bent to form a 90° bend 466. The polyester material forms a window through which light can travel. The sheath material 400 can include

a diffusing element 471 on the window to provide uniform light to an object being imaged. The diffusing element 471 can be mounted to the bent sheath material and have a thickness of 1mm. A mating portion 448 can include an image relay tunnel 120 having an air gap 402 and image relay optics 102 and can be attached to the sheath material 464 such that the matting portion 448 is optically separated from the sheath material 464 at the intersection of both parts 472. In this embodiment, the mating portion 448 does not interconnect with a distal cavity on the endoscope but mounts flush against the distal end of the endoscope. Optical separation of the mating portion 448 from the sheath 400 can be achieved by using an attachment layer 470 such as a black UV adhesive or black epoxy to adhere the mating portion 448 to the sheath material 464 at the intersection 472. The mating portion 448 and the sheath material 464 can form an air space 455. An inner portion of the sheath 400 can include a metalized surface 453. The mating portion can also have a metalized surface 451. The metalized surfaces 453, 451 can be mirror finished to act as a wave guide for the light from the fiber optics 115 of the endoscope 6. The sheath material 464 can include a sheath coating 465 to prevent light from traveling through the outer diameter of the sheath 400. Manufacture of the 0° sheath 400 in this manner allows light to travel from the endoscope 6 through the air space 455 and through the optically transmissive sheath material 464 to an object being imaged.

The mating portions 448 of Figures 22C and 22D can include a metalized surface 451. To form the metalized surface 451, a black coating is formed on the mating portion 448. A metal coating, such as aluminum, is then applied over the black coating. Metalizing the mating portion 448 to a mirrored finish allows light from the fiber optics 115 of the endoscope to reflect within the sheath 400 while protecting the optics 102 within the mating portion 448 from interference caused by the fiber optic light.

The sheath can include a prism located in the air gap 402 which can redirect light 408 to be parallel to the sheath or to the endoscope axis 420. The sheath can include a lens train which can image an object at an oblique angle. Figure 22E shows an embodiment of a 30 degree angle adaptor 430 mounted endoscope 6 where

the sheath includes a lens train 412 and a prism system 414. The optics of the endoscope 6 can have a diameter of 6 mm or less. The prism system 414 can have a first prism portion 416 and a second prism portion 418. The first prism portion 416 and the second prism portion 418 can each be achromatic wedge prisms and can be placed in a low divergence area, such as the air gap 402. The first prism 416 and second prism 418 portions are used to both bend light and recombine colors of the object being imaged simultaneously. The first prism portion 416 and the second prism portion 418 can each be made from a glass material. In one embodiment, either the first prism portion 416 or the second prism portion 418 can be made from flint glass, which has medium index of refraction and a low dispersion. In another embodiment, either the first prism portion 416 or the second prism portion 418 can be made from crown glass, which has high index of refraction and a high dispersion. In a preferred embodiment, the first portion 416 can be made from flint glass while the second prism portion 418 can be made from crown glass. Both types of glass allow for economic disposal of the prism system 414 after use.

The 30° angle adaptor 430 can also have a lens train 412 which can include a shear element 422 and image relay 404 having a first lens 424 and a second lens 426. The shear element 406 and the first 424 and second 426 lens elements can be made from a plastic material. In one embodiment, the lens elements 422, 424, 426 can be made from a plastic material. The lens elements 422, 424, 426 can be made from acrylic because the lens elements 422, 424, 426 can be optically coated and antifog coated. Also acrylic can be an inexpensive material and can provide for economic manufacturing of the elements 422, 424, 426. Because the lens elements 422, 424, 426 can be economically manufactured, they can be disposed after use. The shear element 406 can have a tilted surface 434 and a sheared surface 436.

The shear element 406 can provide an endoscope with a 30° forward view in one embodiment. Current endoscopes having prisms offer a forward view with a blind spot and do not provide a 30° forward view.

Figure 22F illustrates an embodiment of using the 30° angle adaptor 430 on an endoscope 6 in imaging an object 428. Light traversing the air gap 402 parallel to the endoscope axis 420 can be focused by the image relay optics 404 to the center of

the image sensor 106. Thus, light traveling at a 30° angle 440 from the object 428 relative to the endoscope can be deviated to be parallel to the optical axis 420 within the air gap 402 and can appear at the center of the image. Light traveling at a zero degree angle from the object 428 relative to the endoscope 6 can be deviated 7.5 degrees from the optical axis 420 within the air gap 402 and can appear at the left edge of the image. Light traveling at a 60° angle 444 from the object 428 relative to the endoscope can be deviated 7.5 degrees from the optical axis within the air gap 402 and appears at the right edge of the image. With the 30° angle adaptor, a user can view an object at 30° to the axis 420 of the endoscope 6 and can also view straight ahead at 0° to the axis 420 of the endoscope 6.

The 30° angle adaptor 430 provides a user with a 60° field of view. While the field of view shown in Figure 22F has a range between 0° and 60°, relative to the axis 420 of the endoscope 6, other ranges can be viewed using different sheer element 422 to create different adaptors. Fore example, a sheer element 422 can provide a field of view with a range between +30° and -30° or between +55° and -50° relative to the axis 420 of the endoscope 6. In either case, the total field fo view remains at 60°.

Residual astigmatism generated by the achromatic prism 414 can be corrected by the shear element 422 in the distal lens train 412. The small amount of residual chromatic aberration generated by the achromatic prism 414 can be partially corrected by the first 424 and second 426 lens elements in the lens train 412. Further correction of the chromatic aberration can be achieved using decentered, aspheric distal lenses. Since the uncorrected chromatic aberration is not large enough to be noticed in the final image, the first 424 and second 426 lens elements can include two spherical plastic lenses in the lens train.

The achromatic glass prism 418 and the distal lens train 412 which includes image relay optics 404 can be attached to a sheath or adaptor 430 and mounted onto the endoscope 6 as shown in Figure 22G. As shown, the endoscope has a first zoom assembly lens 114 a third zoom assembly lens 116 and a fourth zoom assembly lens 118. The endoscope 6 also has an imaging device 106 and fiber optics 115 for

transmitting light through the endoscope 6. The distal lens train 412 and prism 418 form angle view optics and can be disposed after use.

Figure 22H shows a 30° sheath or adaptor 430 for an endoscope 6. The 30° sheath 430 can act as a second sterile barrier 82 for an endoscope 6. The adaptor 430 includes optical element 452 which allow light traveling from a light source through the endoscope 6 to illuminate an object being imaged. The optical element 452 can bend the light from the light source to correspond with the imaging angle of the sheath. Such bending allows illumination of an object at an angle relative to the endoscope axis 420. The adaptor 430 can include a matting portion 454 that interconnects with a distal cavity on the endoscope 6 or with distal cavity on a first sterile barrier 4.

The 30° sheath 430 can include a light directing mechanism and a window. The light directing mechanism can bend light from fiber optics in an endoscope 6 and direct the light toward an object being imaged at a 30° angle relative to the endoscope 6. The window can permit the light to be directed through the 30° sheath 430.

One embodiment of a 30° sheath 430 having a light directing mechanism and a window 474 is illustrated in Figure 22I. The sheath 430 as shown, is mounted on an endoscope 6. The sheath 430 includes the achromatic prism 414, image relay optics 404, a shear element 422, and a window 474. The window 474 directs light from the fiber optics 115 of the endoscope towards an object being imaged at a 30° angle. The length of the window can be 0.472 inches. The window 474 can be formed by scalloping the sheath 430 and can include a metalized surface 476 which acts as a light directing mechanism and a transparent coating surface 478.

The metalized surface 476 is shaped to optimally transfer light from the fiber optics to an object located at a 30° angle, relative to the endoscope 6. Because the metalized surface 476 is metalized, it allows for reflection of light from the endoscope 6. The transparent coating surface 478 can be formed over both the metalized surface 476 and at least a portion of the fiber optics, as shown at 482. The transparent coating surface 478 can protect the metalized surface and fiber optics of the endoscope 6 when inserted into a biological cavity. The transparent coating

surface 478 can be a plastic material, for example. A front end view of the endoscope 6 having the 30° sheath 430 of Figure 22I is shown in Figure 22J. A cross section of the window 474 shows the area of light disbursement 484 from the fiber optics 115 of the endoscope 6 to the window 474. The endoscope 6 has fiber optics 115 located above 486 the window 474. The light transmitted through this area 486 by the fiber optics 115 can be blocked or can be allowed to exit the 30° sheath 430. As illustrated in Figure 22I, all of the ends of fiber optics 115 which meet the window 474 are straight. Alternately, a portion of the fiber optics 115 ends can be curved to provide illumination directly toward an object being imaged at a 30° angle relative to the endoscope 6. The mating portion 448 of the 30° sheath 430 can have a metalized surface 451. The metalized surface 451 can create a reflective cavity between the endoscope 6 and the 30° sheath 430.

Figure 22K shows another embodiment of a 30° sheath 430 having a light directing mechanism and a window 474. In this embodiment, the light directing mechanism can be an annular mirror 488. The annular mirror 488 can direct light from the fiber optics 115 of the endoscope 6 and toward the window 474, thereby illuminating an object at a 30° angle relative to the endoscope 6. The window 474 can include a transparent coating surface 478, such as a heat shrinkable plastic, for example. The coating surface 478 can protect the window 474 and internal 30° sheath 430 components from potential damage when the sheath 430 and endoscope are inserted into a surgical site.

The prism 414, image relay optics 404 and shear element 422 can be placed into and bonded with a securing mechanism 480 to hold the elements within the sheath 430 and to optically isolate the elements from the light reflecting within the open space 478 of the sheath 430. The securing mechanism 480 can be annular shaped and can be formed from stainless steel. The surface of the stainless steel coating layer 480 can be roughened to a dull matte finish by sandblasting the coating for example. Roughening the finish can help to control the bending of the light within the sheath 480 and present any stray reflections which might be created by a stainless steel securing mechanism 480 having a smooth finish. Stainless steel without a roughened surface can reflect enough light to create strong reelections

within the sheath 430. The inner surface 482 of the sheath 430 can be coated or metalized with a highly reflective material, such as nickel, for example. The reflective coating can increase the refection of light within the open space 478 of the sheath 430. This, in turn, can aid in maximizing the amount of light traveling through the window 474 to illuminate an object being imaged.

A bottom view of the 30° sheath 430 of Figure 22K is shown in Figure 22L. The window 474 has a preferably triangular-shaped area. Such an area can maximize the delivery of light from the endoscope 6 to the object being imaged.

Figure 22M illustrates another embodiment of a 30° sheath having a light directing mechanism and a window 474. In this embodiment, the light directing mechanism includes a first light directing portion 490 and a second light directing portion 492. The first light directing mechanism 490 is preferably an annular mirror while the second light directing portion 492 is preferably an annular prism. Both the first 490 and the second 492 light directing portions are adapted to fit around the mating portion 448 of the 30° sheath 430. The second portion 492 is also adapted to partially fit within the first portion 490.

In an alternate embodiment, either the first light directing portion 490 or the second light directing portion 4923 can be used as the sole light directing mechanism for the 30° sheath 430. Therefore, either an annular prism or an annular mirror can direct light toward the window 474 of the 30° sheath 430.

The window 474 can be coated with a transparent coating surface 478. The coating surface can include a heat shrinkable plastic, for example, and can protect the inner components of the sheath 430 during a surgical procedure.

Figure 22N illustrates a bottom view of the window 474 of the 30° sheath 430 shown in Figure 22M. Both the first 490 and second 492 light directing portions are visible through the window 474 as well as is the mating portion 448 of the 30° sheath 430.

Figure 23 shows an embodiment of a housing 80 for the adaptor 50. In this embodiment, the plurality of lenses 62 can be mounted within the housing 80. A second sterile barrier 82 can be attached to the housing 80. The second sterile

barrier 82 and the housing 80 can fit over and can be secured to a first sterile barrier 4 which, in turn can be secured over a laparoscope 6.

Figure 24 shows an alternate embodiment for a housing 84 for the adaptor 50. In this embodiment, a housing 84 containing the plurality of lenses 62 and the prism 56 connects to a rigid tube 26 located at the distal end of the first sterile barrier 4. In a preferred embodiment, the housing 84 is removably attached to the rigid tube 26 by an attachment mechanism 34. The attachment mechanism 34 can be threaded.

Figures 25A and 25B illustrate an embodiment of an endoscope 6 and first sterile barrier 4, respectively, where each has a distal end distal cavity portions. A cross-sectional view of the endoscope 6 is shown in Figure 25A. The distal end 20 of the endoscope 6 can have a distal cavity portion 456 which can receive a first sheath mating portion 458, a second sheath mating portion 448 or a combination of both mating portions 458,448. Light from fiber optics 115 of the endoscope can exit the endoscope 6 further distal than light entering the optics 112, 114, 116, 118. Such a feature can be created by the distal cavity portion 456.

Figure 25B shows a cross-sectional view of a first sterile barrier 4. The barrier 4 includes both a mating portion 458 and a distal cavity portion 460 located at its distal end. The mating portion 458 can be plug-shaped and can fit into the distal cavity portion 456 of the endoscope 6, as shown in Figure 11C. The distal cavity portion 460 can receive a mating portion of a second sterile barrier 82 such as the mating portion 448 of the 0° angle adaptor 400 and the mating portion 454 of the 30° angle adaptor 430, as shown in Figure 19C and 19G, respectively.

The feature of disposability can be applied to some of the elements of the present invention such as the distal optics 20, the rigid tube 26, the primary sterile barrier 82, the second sterile barrier 4 and the adaptor 50. By using disposable portions for each procedure, the laparoscope base unit 6 does not have to be sterilized after each operation. The base unit 6 can be used for subsequent patients while maintaining the sterility of the base unit 6.

The endoscope can also have square or rectangularly shaped optics to form a virtual image of an object being examined. By using square optics, a more efficient

transfer of light can be made from an object being viewed to an imaging device, which has a square or rectangular imaging area. Figure 25 illustrates an endoscope with rectangular optics. The rectangular lenses for the endoscope are shown as the zoom assembly 104, which includes the first zoom assembly lens 112, the second zoom assembly lens 114, the third zoom assembly lens 116 and the fourth zoom assembly lens 118. All light rays 90 from the rectangular zoom assembly 104 can be transferred to the image device 84. More light from the object being imaged can therefore be transferred to the image device 84 with little waste. A square or rectangular shaped transmission path can be used to transfer the light from the optics 88 to the imaging device 84. Also, image relay optics on a primary sterile barrier can be formed as square or rectangular. Similarly, the prism and distal lens train of a 30° adaptor 430 can be square.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

CLAIMS

What is claimed is:

1. An endoscope comprising:

an endoscope having a probe, a handle, an optical system, an illumination channel and an imaging device, the probe having a proximal end and a distal end;

a first sheath having a proximal end and a distal end, the first sheath covering the probe of the endoscope; and

a second sheath that covers the first sheath and the probe of the endoscope, the second sheath having an optical element that directs light to the optical system.

2. The endoscope of Claim 1 further comprising a zoom assembly that translates a lens of the optical system.

3. The endoscope of Claim 2 wherein the optical system comprises at least four lenses including a first lens element, a second lens element, a third lens element and a fourth lens element.

4. The endoscope of Claim 3 wherein the first lens element and the third lens element remain stationary relative to the handle during a zooming procedure.

5. The endoscope of Claim 3 wherein the second lens element and the fourth lens element translate during a zooming procedure.

6. The endoscope of Claim 1 further comprising a connector that attaches the second sheath to the first sheath.

7. The endoscope of Claim 6 wherein the connector allows rotation of the second sheath relative to the handle.

8. The endoscope of Claim 1 further comprising a connector that attaches the first sheath to the endoscope handle.

9. The endoscope of Claim 1 further comprising distal connector at the distal end of the second sheath that connects the optical element to the second sheath.

10. The endoscope of Claim 1 wherein the first sheath comprises a mating portion and a distal cavity that receives a portion of the second sheath.

11. An endoscope comprising:

an endoscope having a probe, a handle, a zoom optical system, an illumination channel and an imaging device, the probe having a proximal end and a distal end;

a first sheath having a proximal end and a distal end, the first sheath extending over the probe and the handle of the endoscope; and

a second sheath that extends over the first sheath and the probe of the endoscope such that the imaging sensor receives an image from an image relay optical device.

12. The endoscope of Claim 11 wherein the optical system comprises a series of at least four lenses including a first lens element, a second lens element, a third lens element and a fourth lens element and wherein the optical system mounts onto a zoom assembly.

13. The endoscope of Claim 12 wherein the first lens element and the third lens element remain stationary during a zooming procedure.

14. The endoscope of Claim 12 wherein the second lens element, the fourth lens element and the imaging device translate during a zooming procedure.

15. The endoscope of Claim 11 further comprising a connector that attaches the second sheath to the first sheath.

16. The endoscope of Claim 11 further comprising a connector that attaches the first sheath to the endoscope handle.

17. The endoscope of Claim 11 wherein the second sheath comprises a plastic material having a window that allows light to be transmitted from the endoscope.

18. A method of using an endoscope comprising;

providing an endoscope;
placing a first sheath on the endoscope;
placing a second sheath onto the first sheath;
inserting the endoscope into a region of interest; and
viewing the region of interest with the endoscope.

19. The method of Claim 18 further comprising disposing of the first sheath and the second sheath and reusing the endoscope to view a region of interest.

20. The method of Claim 18 further comprising providing an endoscope having a probe, a handle, a zoom optical system an illumination channel connected to a light source and an imaging device.

21. An endoscope comprising:

an endoscope having a probe, a handle, an optical system, an illumination channel and an imaging device, the probe having a proximal end and a distal end;

a first sheath having a proximal end and a distal end, the first sheath extending over the probe; and

a second sheath that extends over the first sheath and the probe of the endoscope, the second sheath having an angle adaptor that collects light from a region of interest at an oblique angle relative to a central axis of the endoscope probe.

22. The endoscope of Claim 21 wherein the endoscope further comprises a zoom optical system and a zoom actuator.

23. The endoscope of Claim 21 wherein the optical system comprises at least four lenses including a first lens element, a second lens element, a third lens element and a fourth lens element.

24. The endoscope of Claim 23 wherein the first lens element and the third lens element remain stationary during a zooming procedure.

25. The endoscope of Claim 23 wherein the second lens element, the fourth lens element and the imaging device translate during a zooming procedure.

26. The endoscope of Claim 21 further comprising a connector that attaches the second sheath to the first sheath.

27. The endoscope of Claim 26 wherein the connector allows rotation of the second sheath and the angle adaptor about the central axis of the endoscope.

28. The endoscope of Claim 21 further comprising a connector that attaches the first sheath to the endoscope handle.

29. The endoscope of Claim 21 wherein the angle adaptor comprises a lens element and a prism.

30. The endoscope of Claim 21 wherein the angle adaptor comprises a window wherein the window passes light from the endoscope to a region of interest positioned at an oblique angle relative to a longitudinal axis of the endoscope.

31. The endoscope of Claim 30 wherein the window comprises a transparent coating surface.

32. The endoscope of Claim 21 wherein the angle adaptor comprises a light directing system.

33. The endoscope of Claim 32 wherein the light directing system comprises a metalized surface.

34. The endoscope of Claim 32 wherein the light directing system comprises an annular mirror.

35. The endoscope of Claim 32 wherein the light directing system comprises an annular mirror and an annular prism.

36. The endoscope of Claim 32 wherein the light directing system comprises an annular prism.

37. A method of viewing a region of interest comprising:

providing an endoscope having an optical system, a first sheath, and a second sheath having a viewing angle adaptor;

connecting the first sheath to the endoscope;

connecting the second sheath to the first sheath;

positioning the endoscope to view a region of interest; and

viewing the region of interest at an angle relative to a longitudinal axis of the endoscope.

38. The method of Claim 37 further comprising zooming the optical system to obtain a magnified view of the region of interest.

39. The method of Claim 37 further comprising providing an endoscope having a probe, a handle, a zoom actuator an illumination channel and an image device.

40. The method of Claim 37 further comprising an illumination window on a distal annular surface of the probe.

41. A sheath system for an endoscope comprising:

a first sheath having a proximal end and a distal end, and a connector that attaches the first sheath to an endoscope; and

a second sheath that can be inserted over the first sheath and having a sheath connector.

42. The sheath system of Claim 41 wherein the second sheath comprises an optical system.

43. The sheath system of Claim 42 wherein the optical system comprises a first lens element and a second lens element.

44. The sheath system of Claim 41 wherein the first sheath comprises a plastic material.

45. The sheath system of Claim 41 wherein the first sheath further comprises a flexible sleeve attached to the connector.

46. A sheath kit for an endoscope comprising:

a first sheath having a proximal end and a connector that attaches the first sheath to an endoscope; and

a second sheath that extends over the first sheath.

47. The kit of Claim 46 further comprising a third sheath having an angle adaptor attached to the distal end of the third sheath.

48. The kit of Claim 47 wherein the angle adaptor comprises a lens and a prism.

49. The kit of Claim 47 wherein the angle adaptor comprises a first lens and a second lens.

50. The kit of Claim 47 wherein the angle adaptor comprises a window wherein the window can pass light onto an object being viewed at an oblique angle relative to an axis of the first sheath.

51. The kit of Claim 50 wherein the window comprises a transparent coating surface.

52. The kit of Claim 47 wherein the angle adaptor comprises a light directing system.

53. The kit of Claim 51 wherein the light directing system comprises a metalized surface.

54. The kit of Claim 52 wherein the light directing system comprises an annular mirror.

55. The kit of Claim 52 wherein the light directing system comprises an annular mirror and an annular prism.

56. The kit of Claim 52 wherein the light directing system comprises an annular prism.

57. The kit of Claim 46 wherein the second sheath has a lens that collects light along a longitudinal axis of the first sheath.

58. A method of using a sheath system comprising;

providing a first sheath;

connecting a second sheath onto the first sheath;

using the sheath system to view a region of interest; and

replacing the first sheath with a third sheath.

59. The method of Claim 58 further comprising providing a third sheath having a viewing angle adaptor.

60. The method of Claim 58 further comprising providing a third sheath with a 0° viewing angle.

61. An endoscope comprising:

an endoscope having a probe, a handle, an optical system, including an image relay having a light absorbing inner surface, and an imaging device, the probe having a proximal end and a distal end; and

a primary sheath having a proximal end and a distal end, the primary sheath covering the probe of the endoscope.

62. The endoscope of Claim 61 further comprising a second sheath that covers the sheath and the probe of the endoscope, the second sheath having an optical element that directs light to the optical system.

63. The endoscope of Claim 61 further comprising a zoom assembly that translates a lens of the optical system.

64. The endoscope of Claim 63 wherein the optical system comprises at least four lenses including a first lens element, a second lens element, a third lens element and a fourth lens element.

65. The endoscope of Claim 64 wherein the first lens element and the third lens element remain stationary relative to the handle during a zooming procedure.

66. The endoscope of Claim 64 wherein the second lens element and the fourth lens element translate during a zooming procedure.

67. The endoscope of Claim 62 further comprising a connector that attaches the second sheath to the primary sheath.

68. The endoscope of Claim 62 wherein the connector allows rotation of the second sheath relative to the handle.

69. The endoscope of Claim 61 further comprising a connector that attaches the primary sheath to the endoscope handle.

70. The endoscope of Claim 62 further comprising distal connector at the distal end of the second sheath that connects the optical element to the second sheath.

71. The endoscope of Claim 62 wherein the primary sheath comprises a mating portion and a distal cavity that receives a portion of the second sheath.

72. An endoscope comprising:

an endoscope having a probe, a handle, a zoom optical system, an illumination channel, an image relay having a light altering inner surface, and an imaging device, the probe having a proximal end and a distal end; and

a first sheath having a proximal end and a distal end, the first sheath extending over the probe and the handle of the endoscope;

73. The endoscope of Claim 72 further comprising a second sheath that extends over the first sheath and the probe of the endoscope such that the imaging sensor receives an image from the image relay.

74. The endoscope of Claim 72 wherein the optical system comprises a series of at least four lenses including a first lens element, a second lens element, a third lens element and a fourth lens element and wherein the optical system mounts onto a zoom assembly.

75. The endoscope of Claim 74 wherein the first lens element and the third lens element remain stationary during a zooming procedure.

76. The endoscope of Claim 74 wherein the second lens element, the fourth lens element and the imaging device translate during a zooming procedure.

77. The endoscope of Claim 73 further comprising a connector that attaches the second sheath to the first sheath.

78. The endoscope of Claim 72 further comprising a connector that attaches the first sheath to the endoscope handle.

79. The endoscope of Claim 73 wherein the second sheath comprises a plastic material having a window that allows light to be transmitted from the endoscope.

80. The endoscope of Claim 72 wherein the light altering inner surface comprises a tubular air channel having a length between 10 and 40 mm, the inner surface reducing non-collimated light directed through the channel.

81. The endoscope of Claim 72 wherein the inner surface comprises a roughened surface.

82. The endoscope of Claim 72 wherein the inner surface comprises a light absorbing layer within a cylindrical channel optically coupled to an aperture.

83. The endoscope of Claim 72 wherein the handle comprises a mechanical zoom actuator and an optical coupler that is coupled to a light source.

84. The endoscope of Claim 72 further comprising a relay optical system within an image relay channel.

85. The endoscope of Claim 84 wherein the relay optical system comprises a prism.

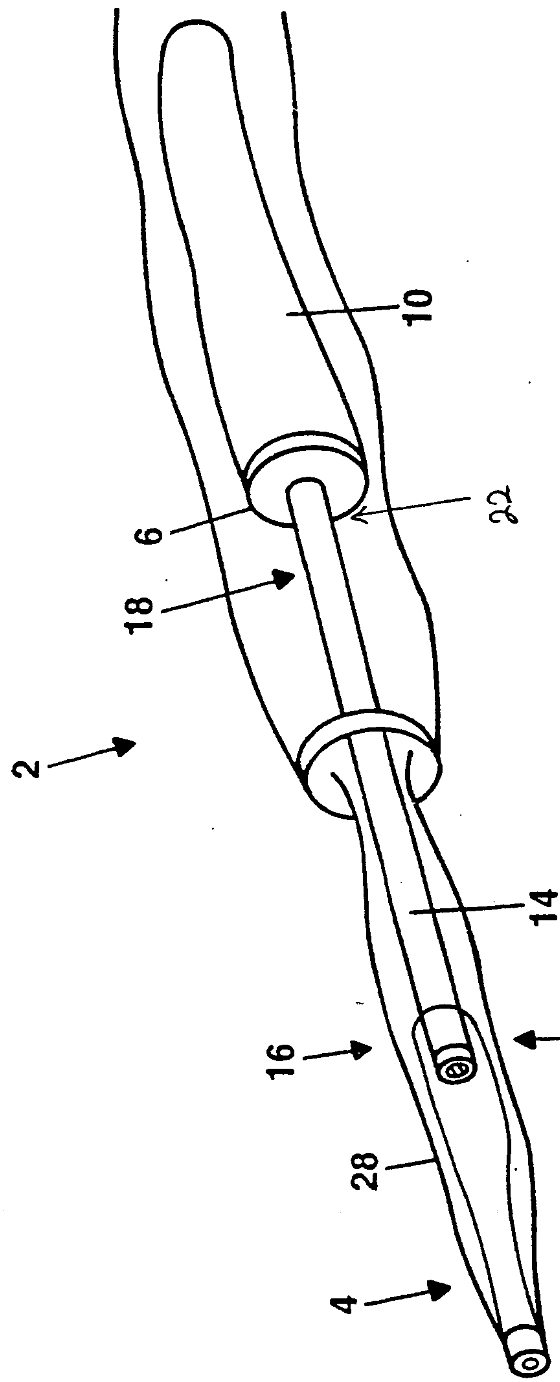
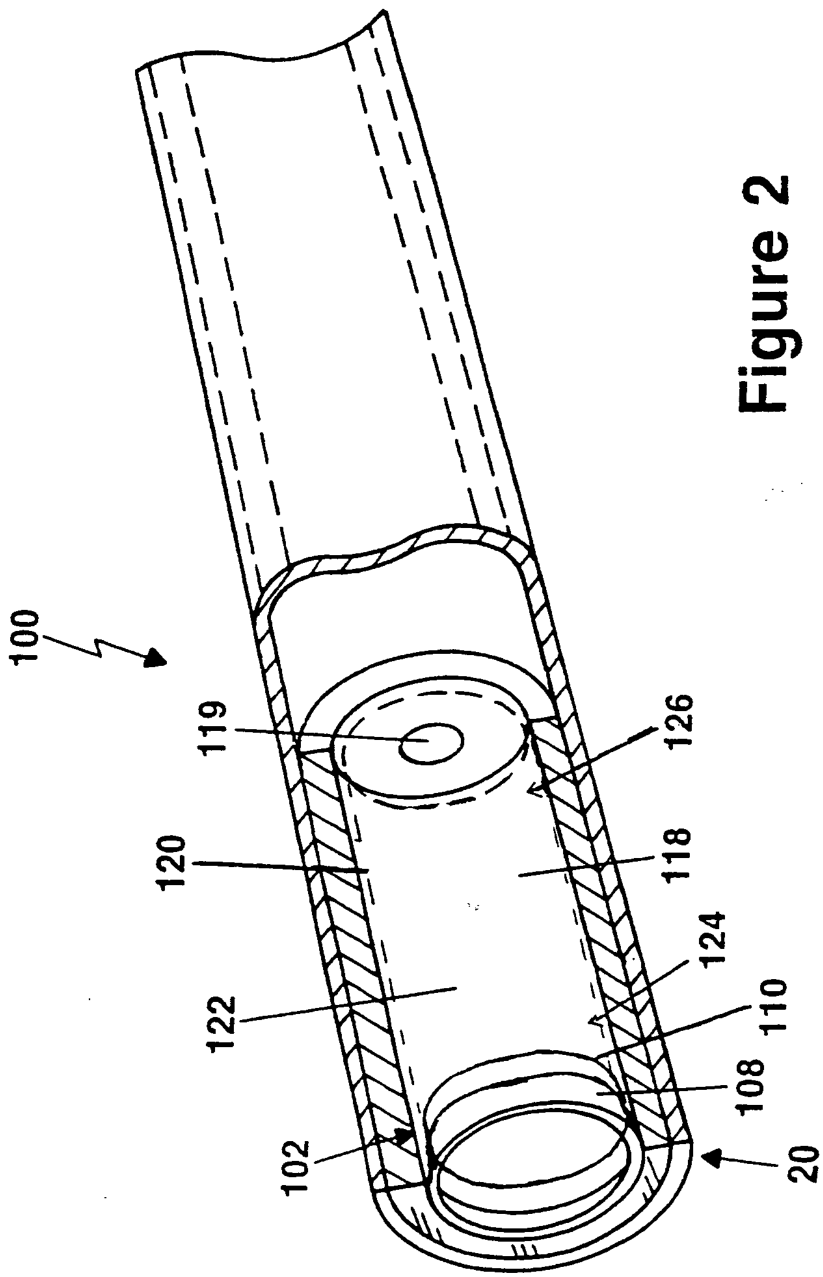


Figure 1



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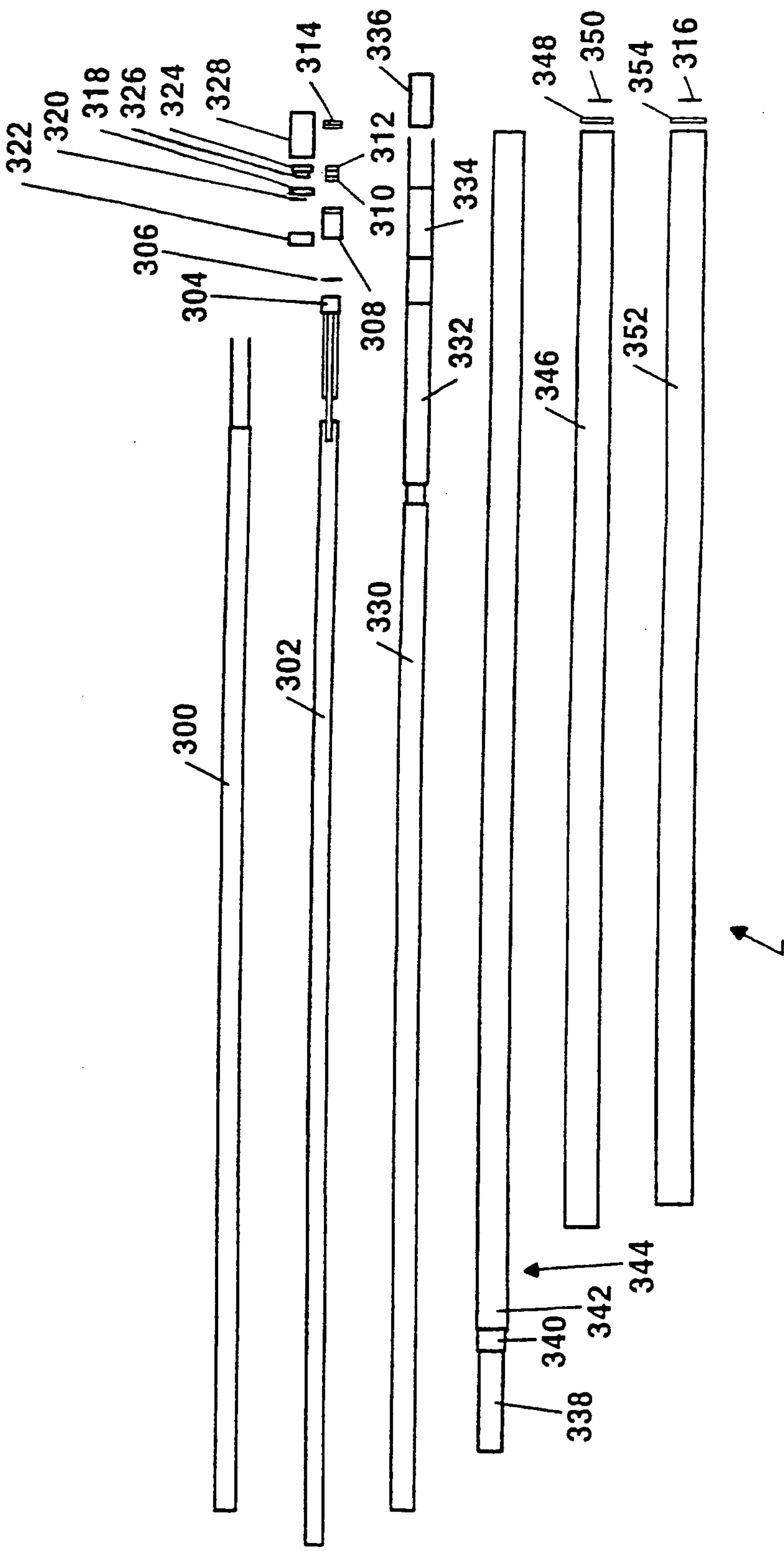
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Figure 3A

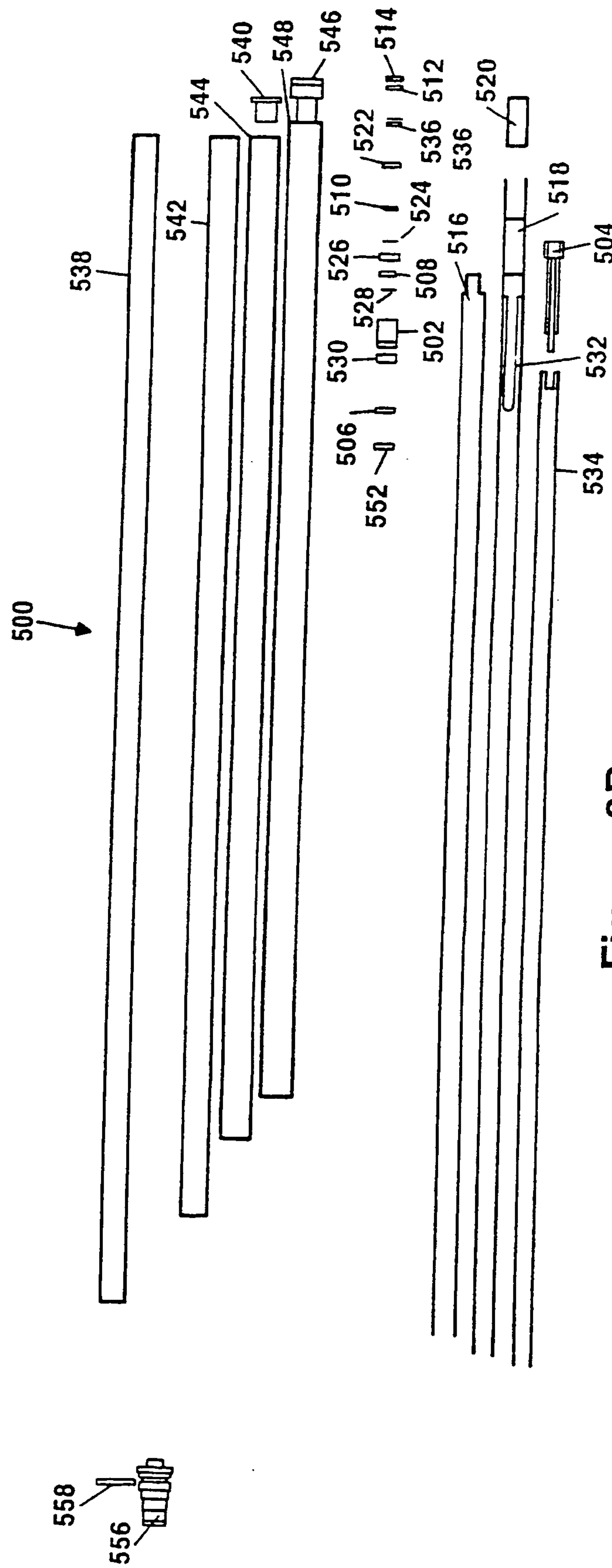
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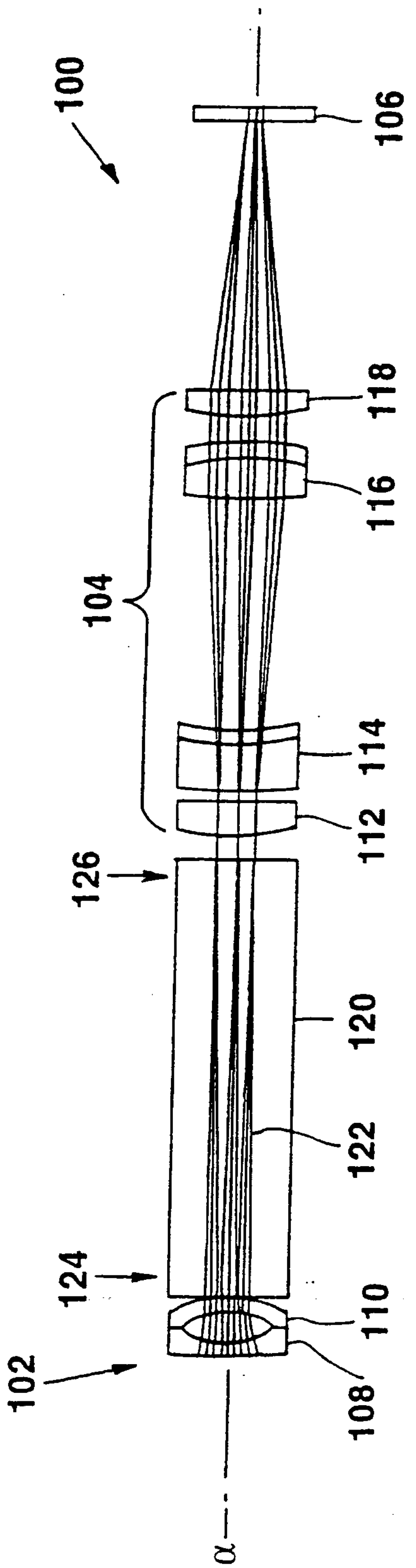
Figure 3B



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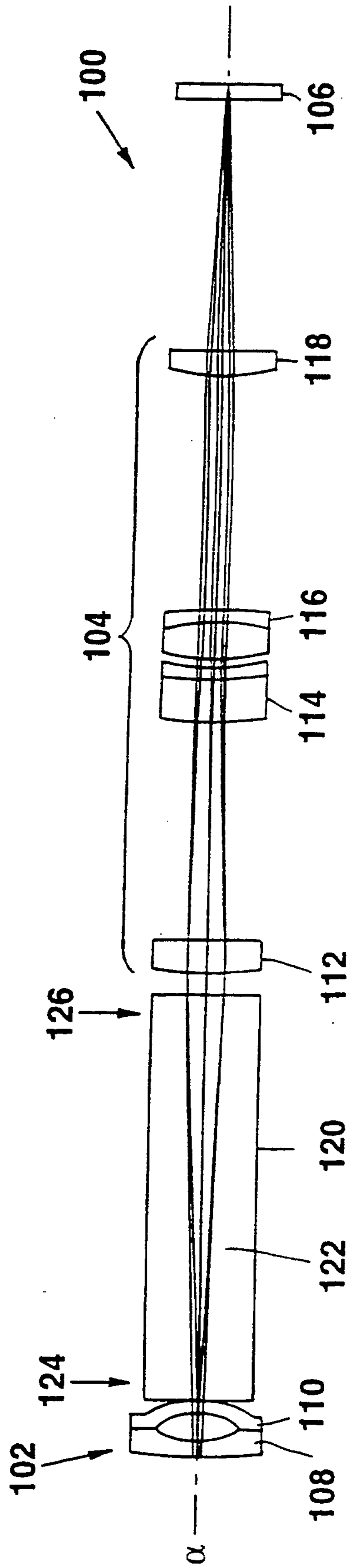

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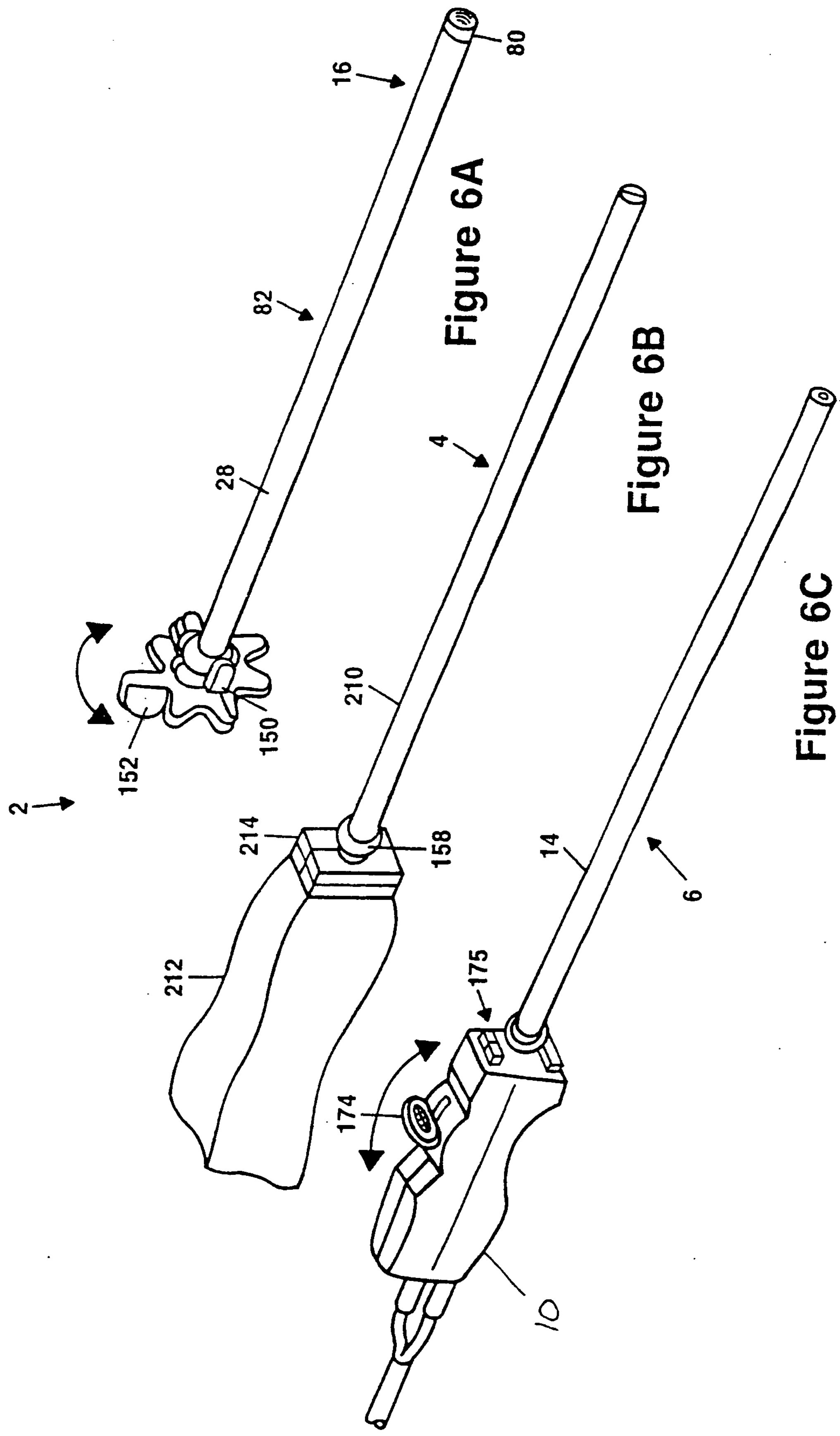
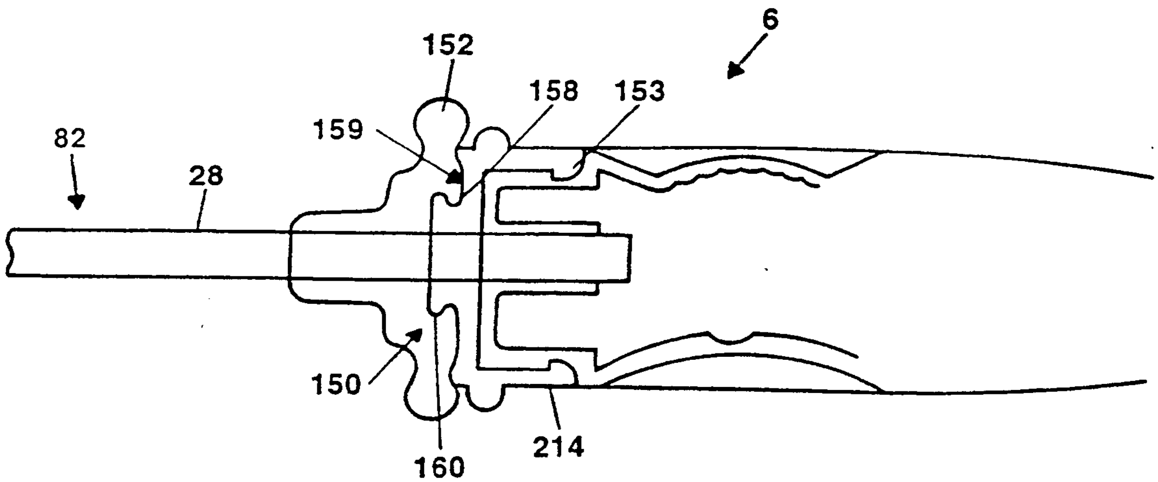


Figure 6A

Figure 6B

Figure 6C



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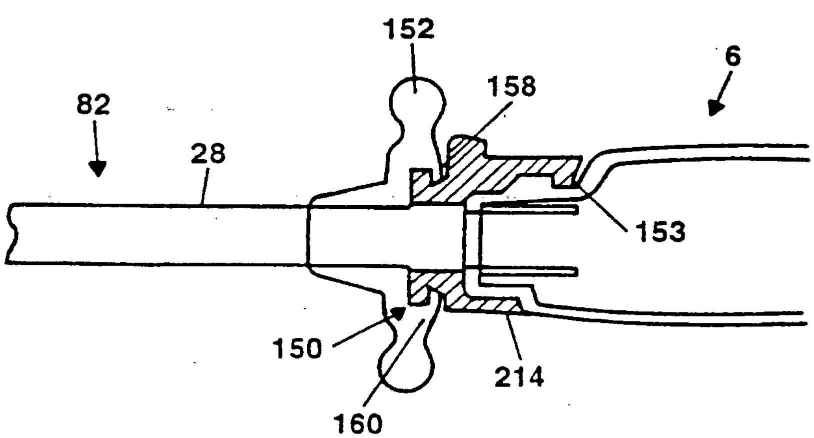

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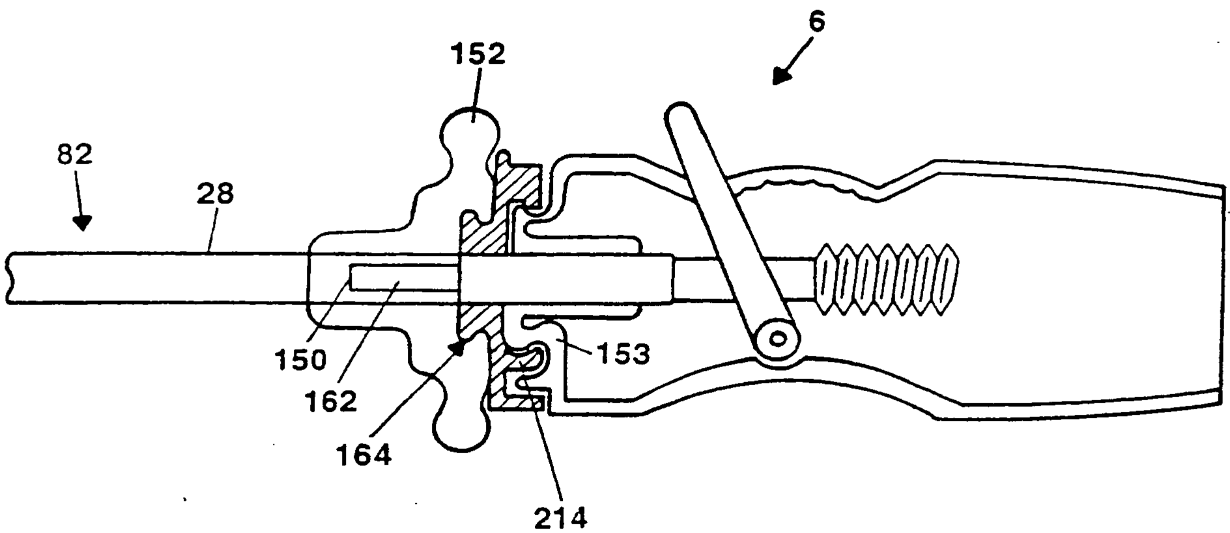

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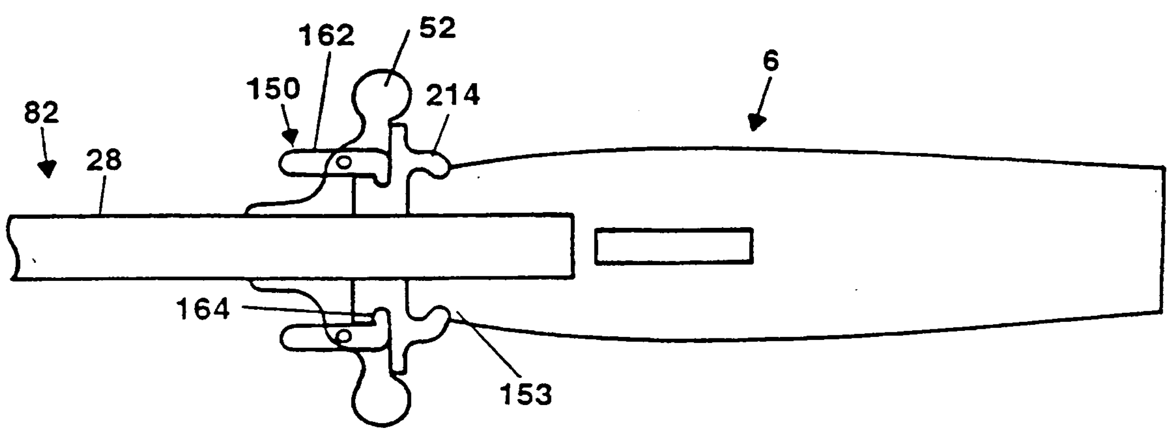

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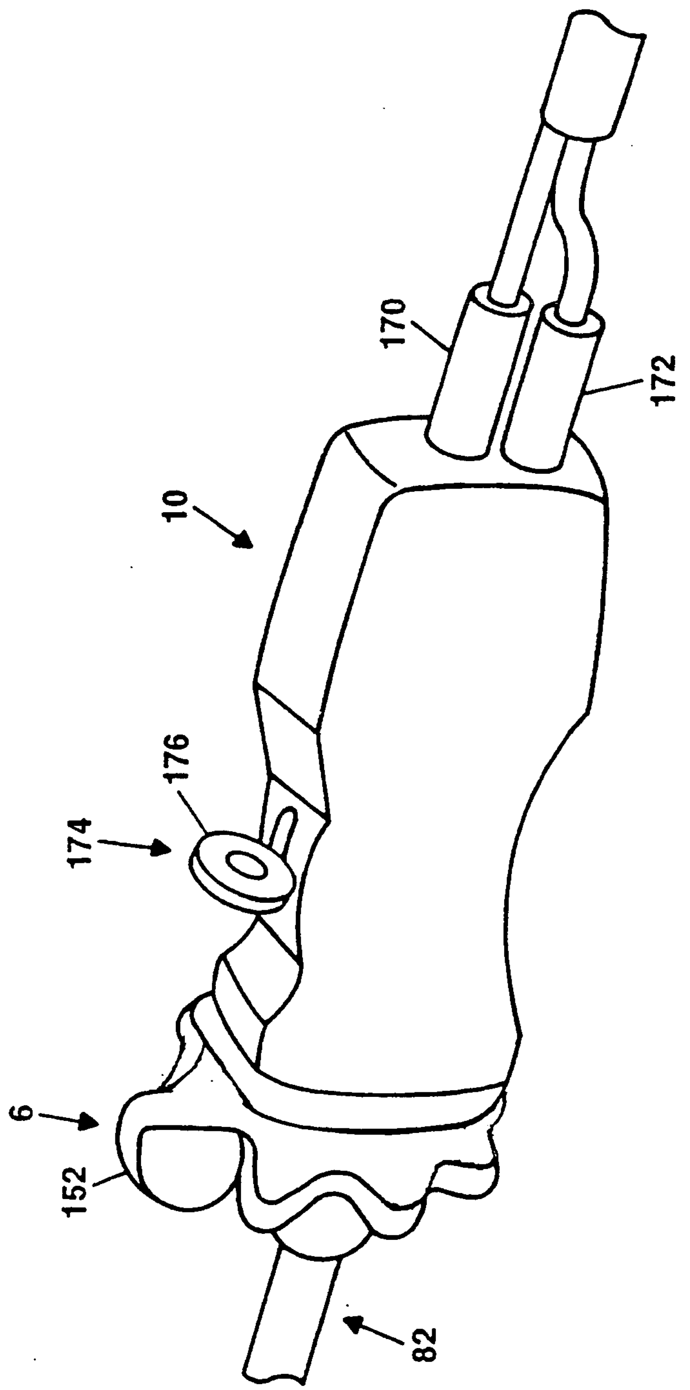

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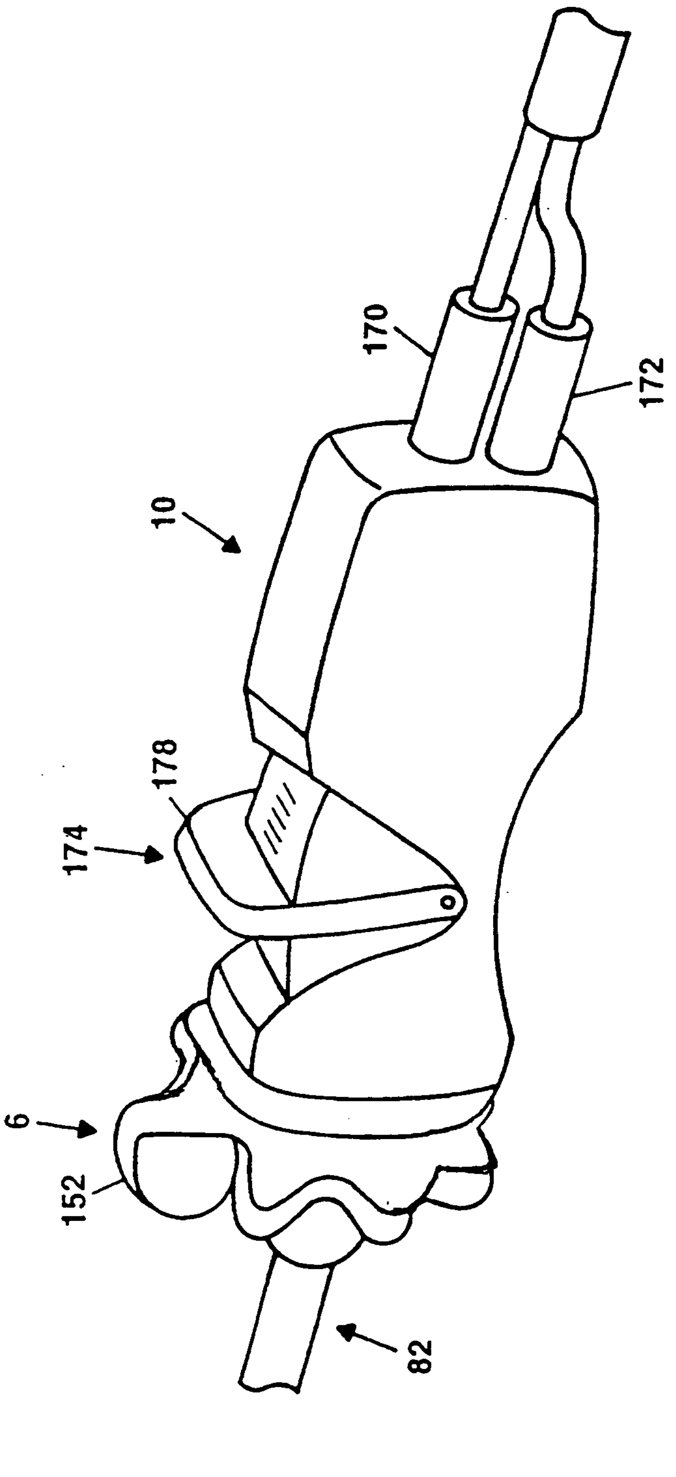
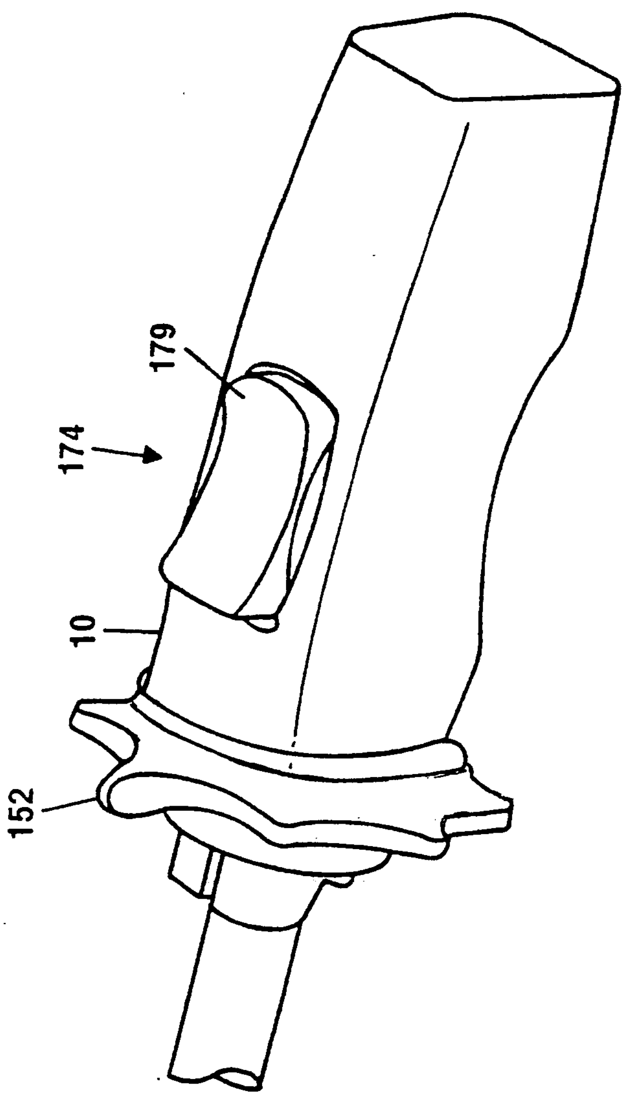


Figure 12A



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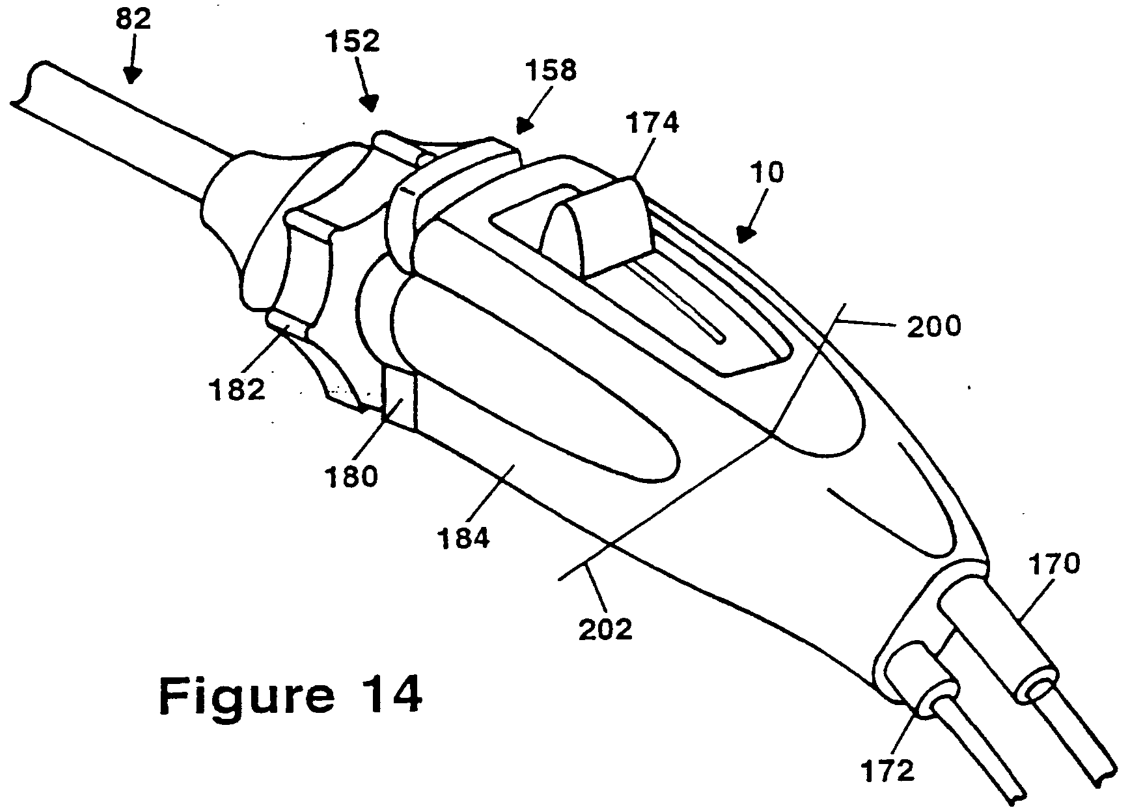
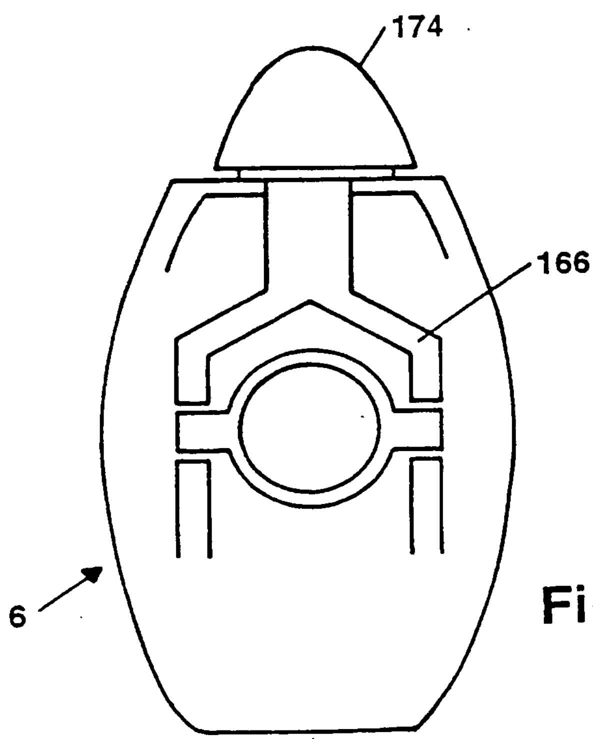


Figure 14



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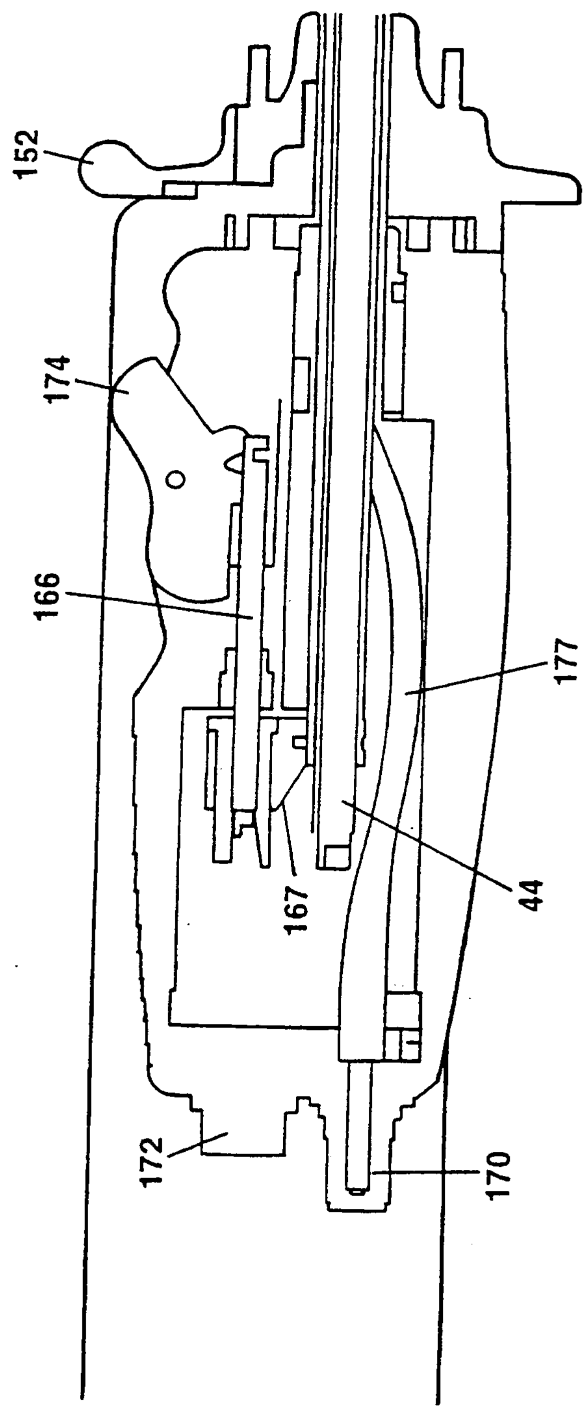

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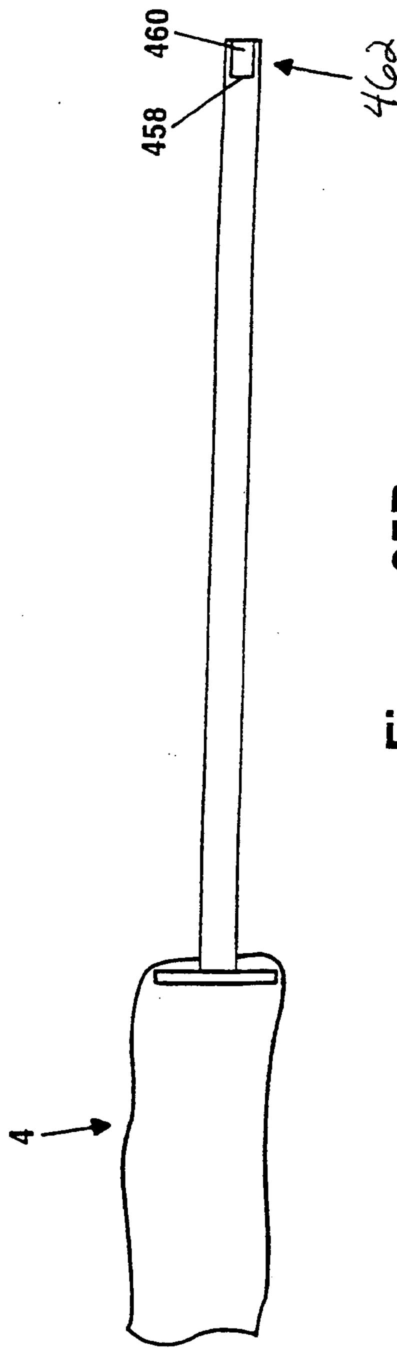
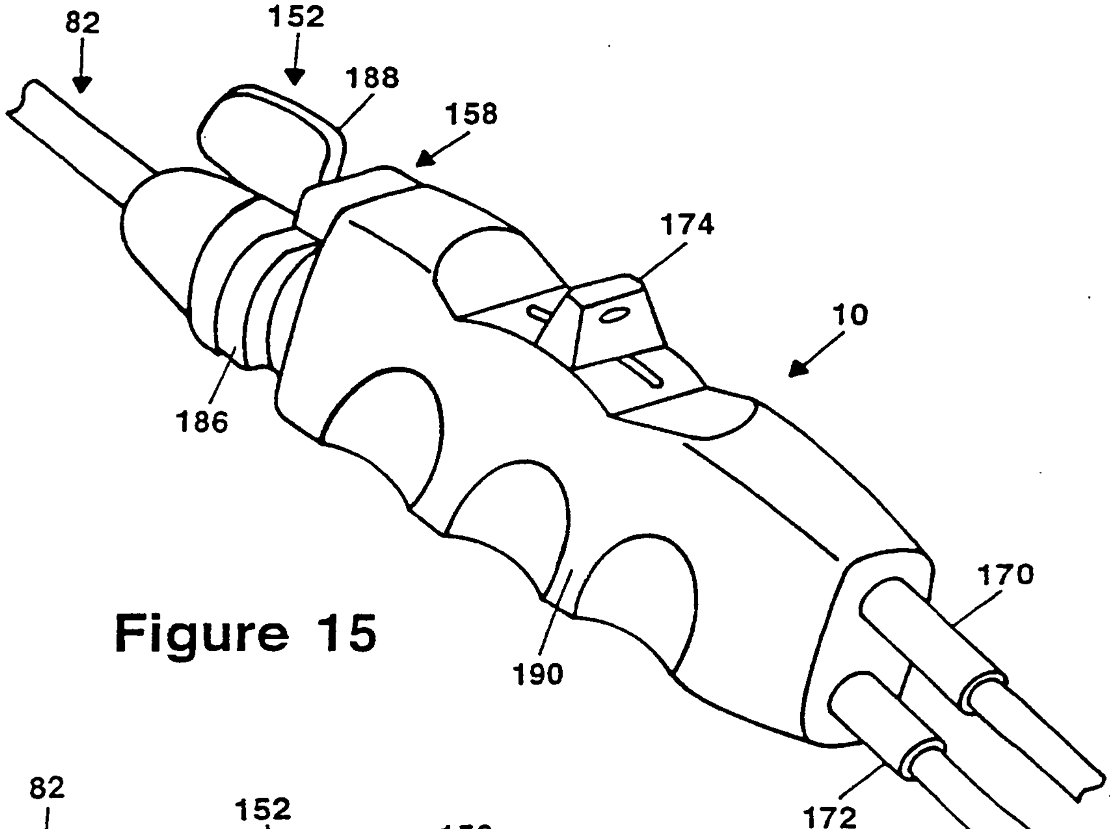


Figure 25B



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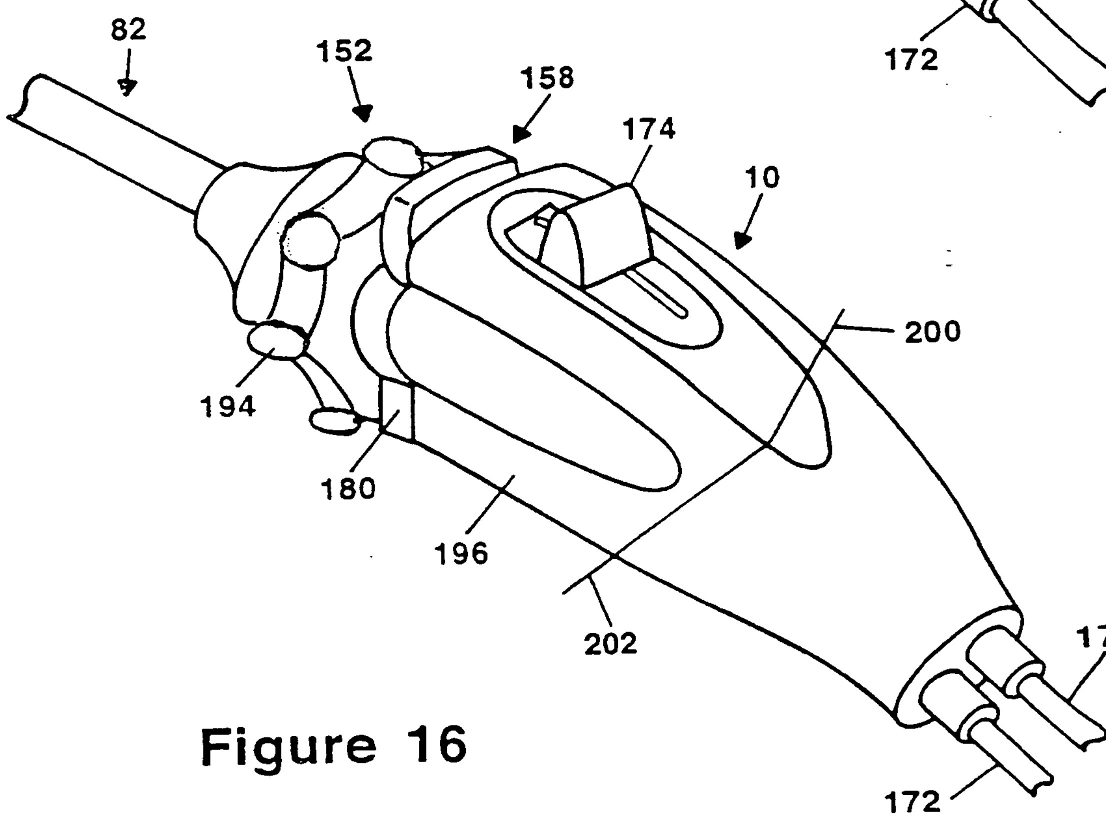

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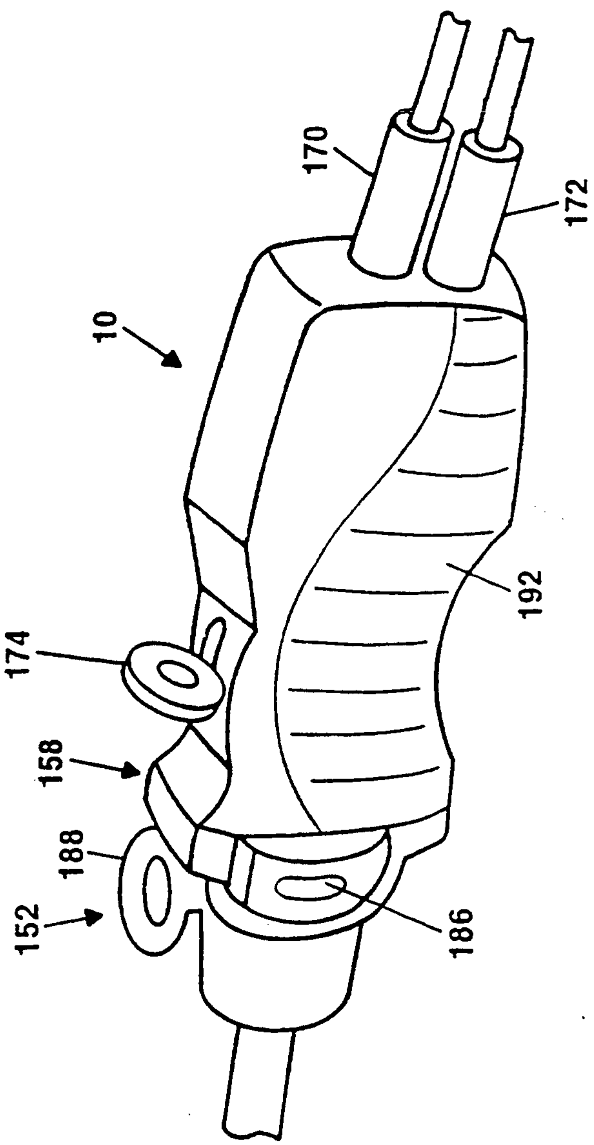

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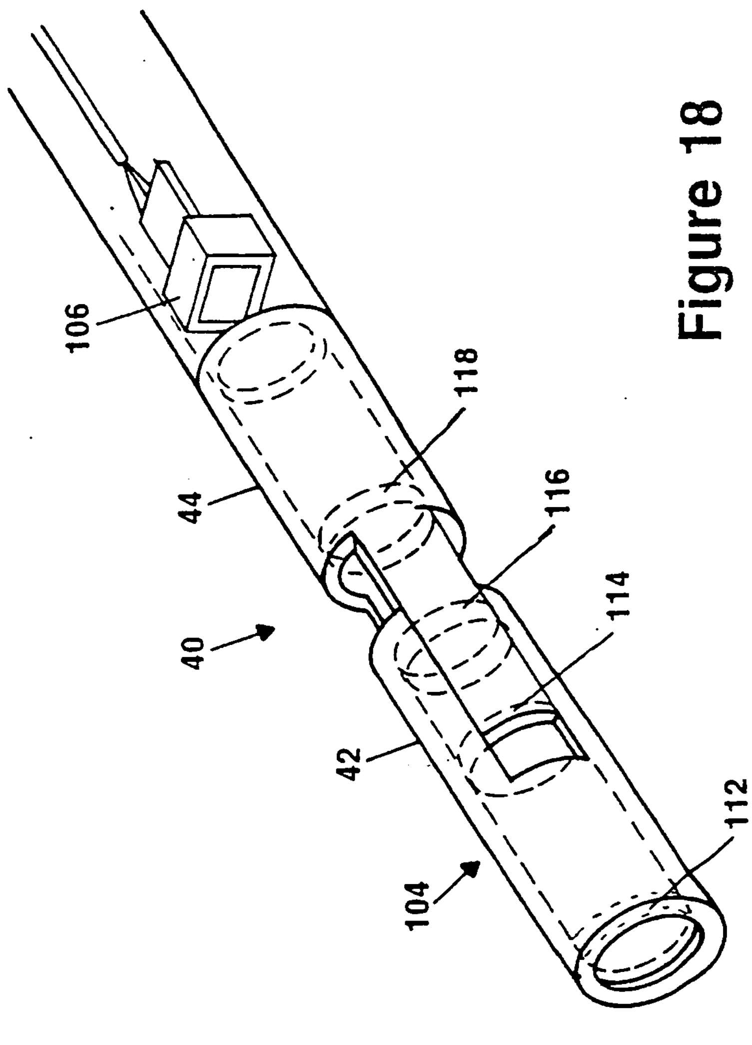

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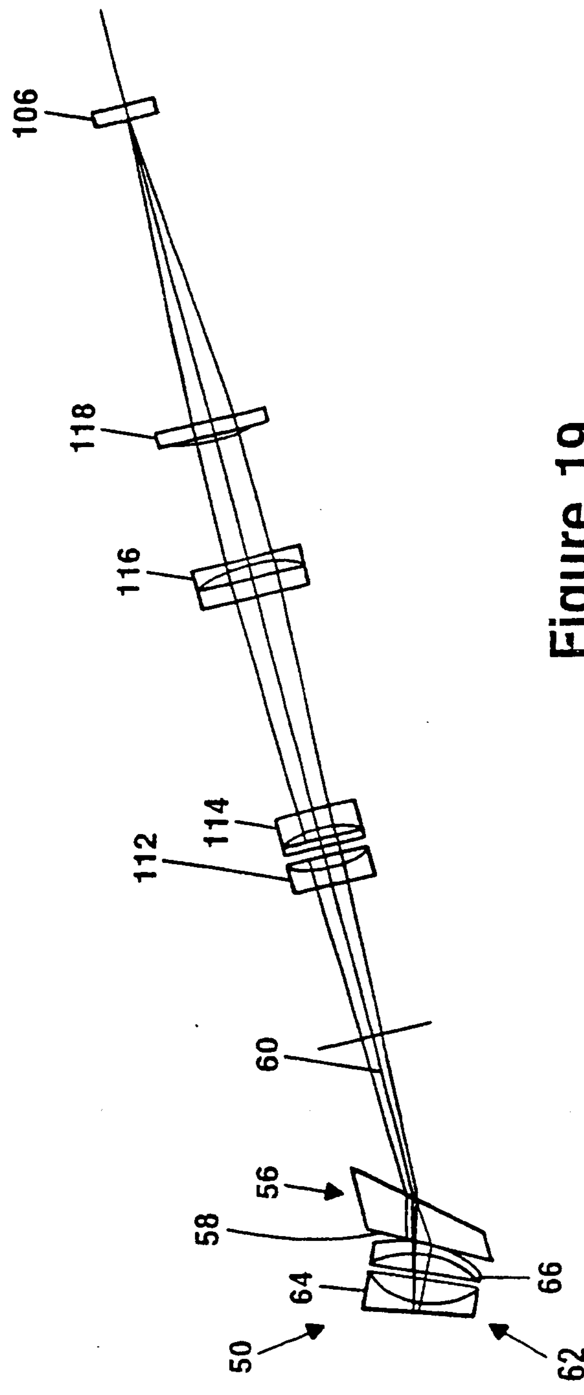

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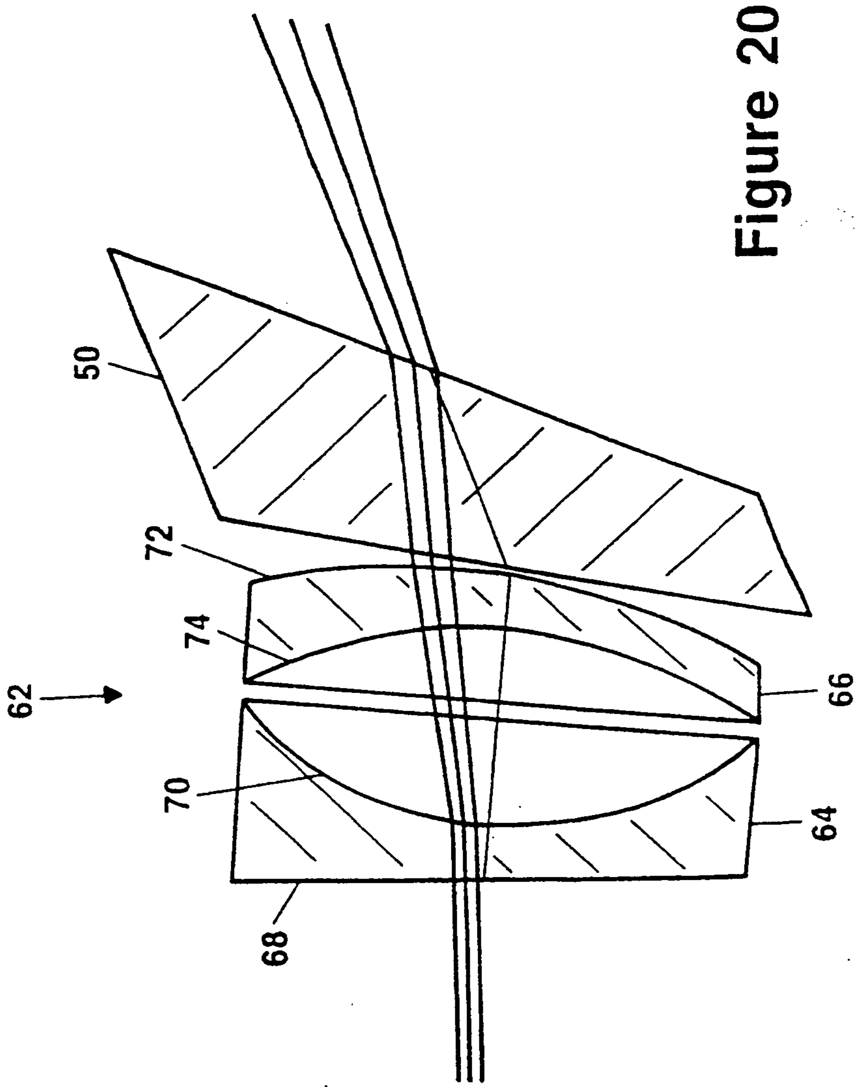

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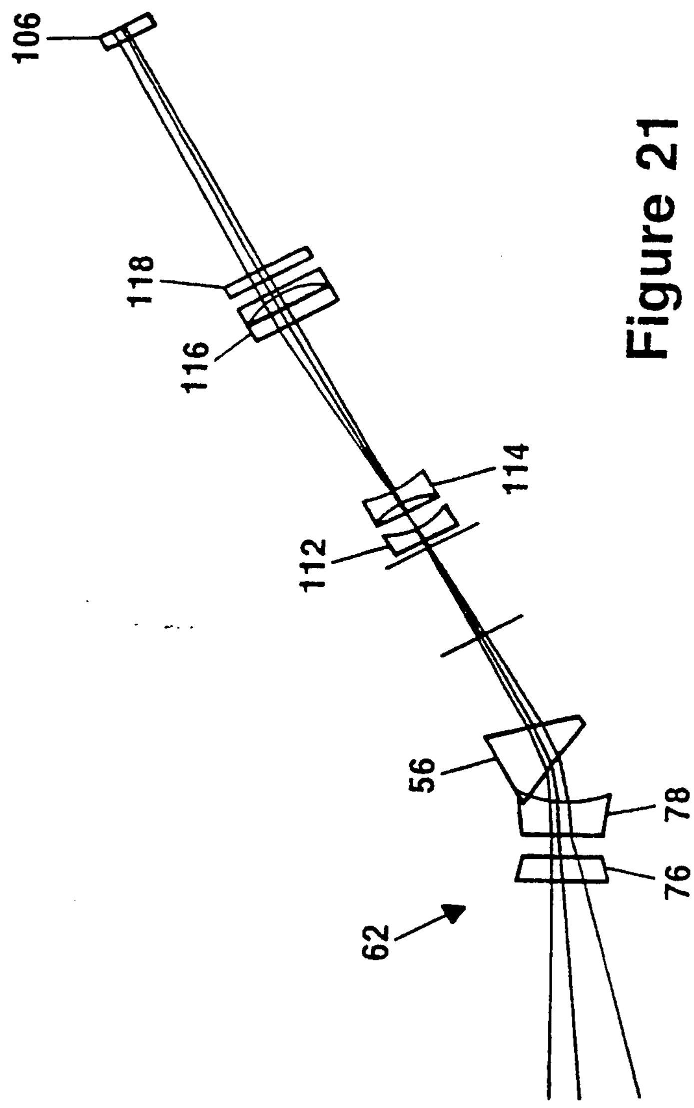

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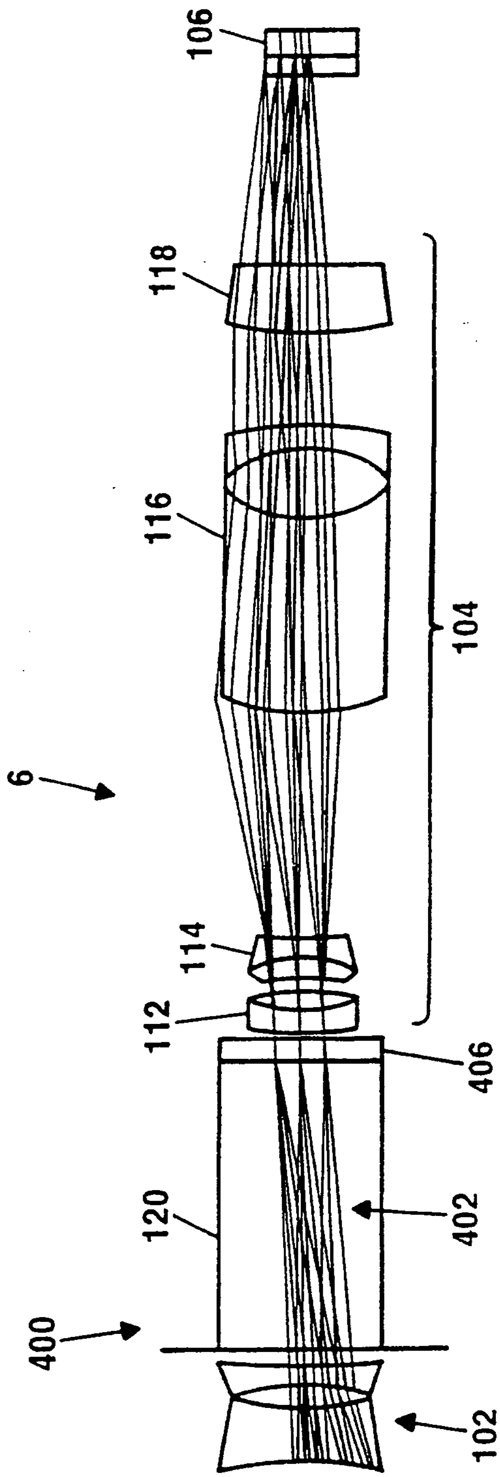
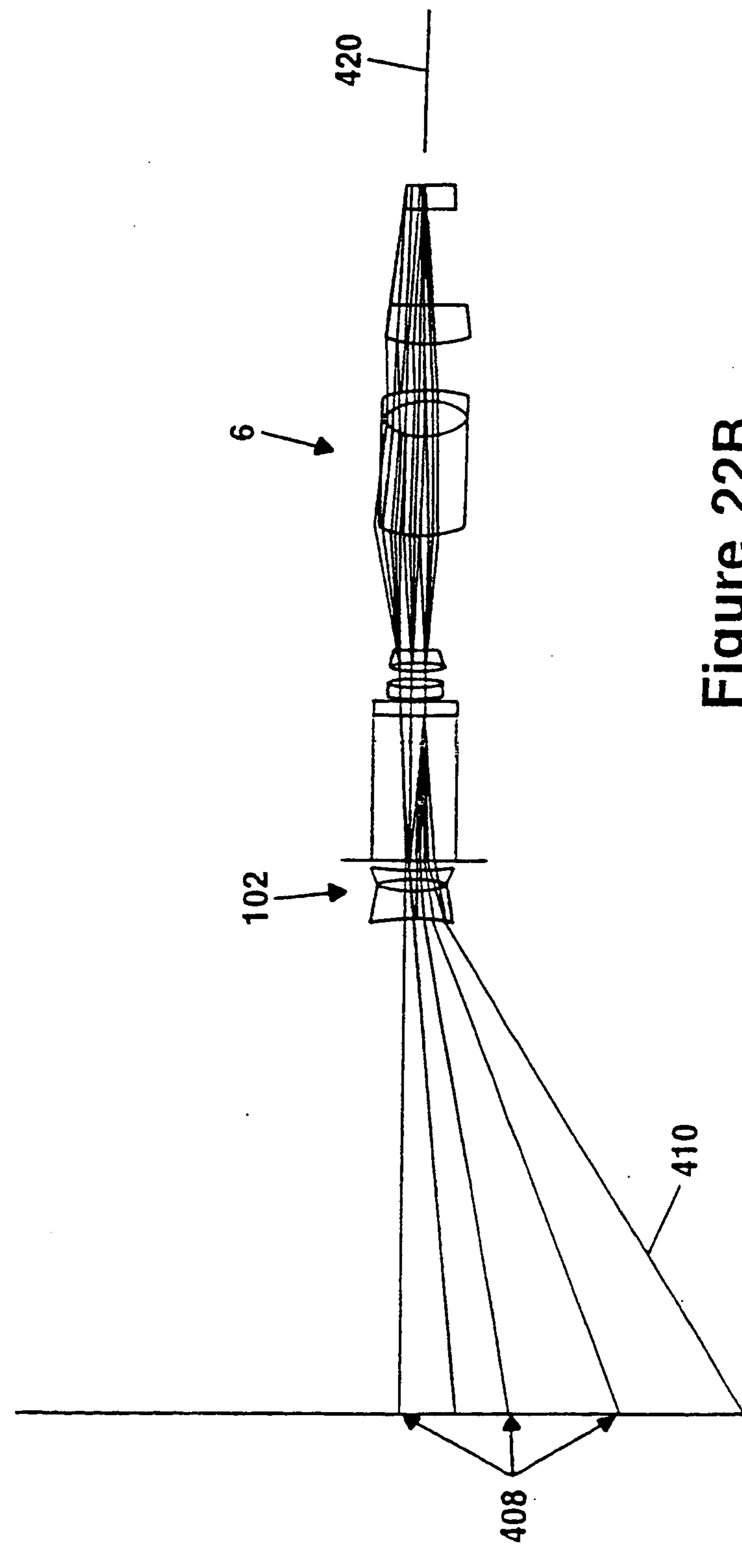


Figure 22A



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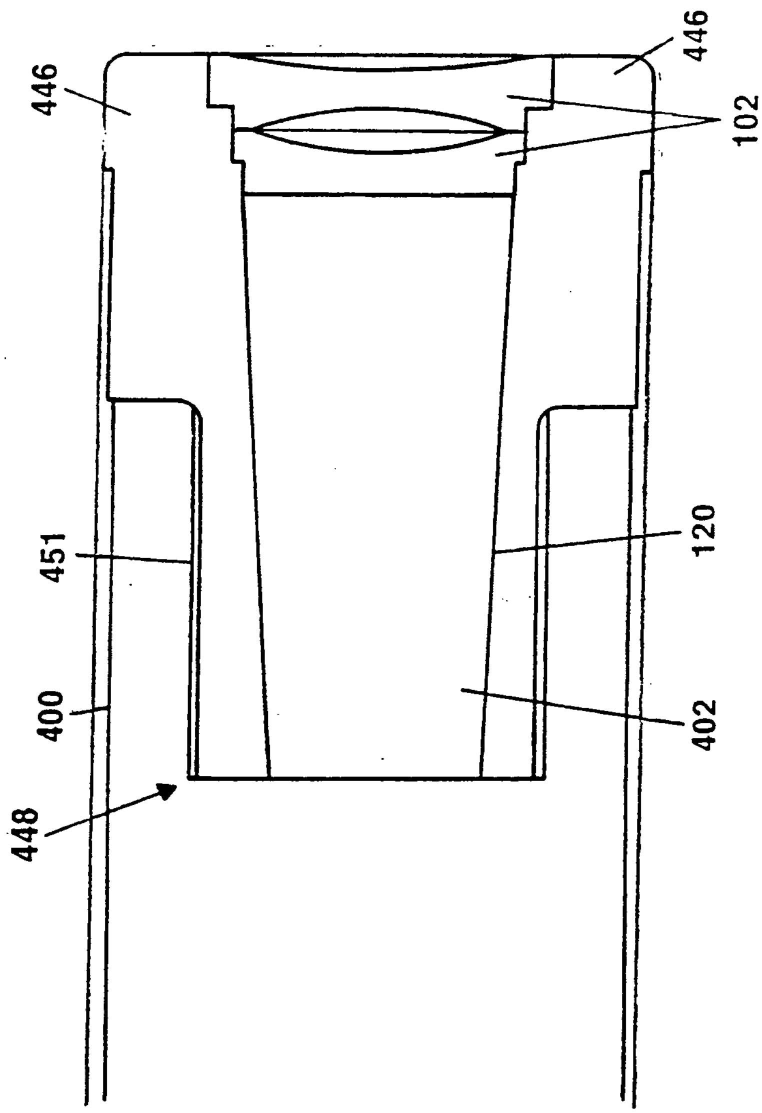

Figure 22C

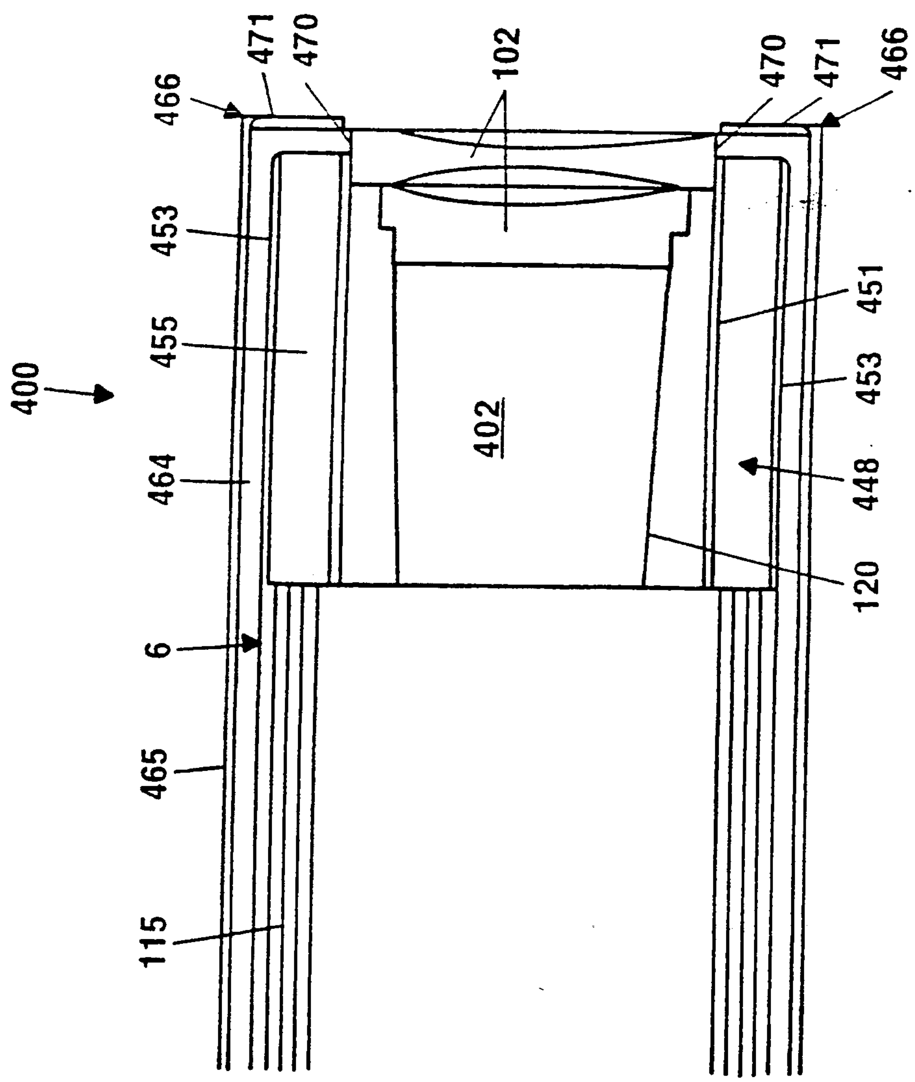
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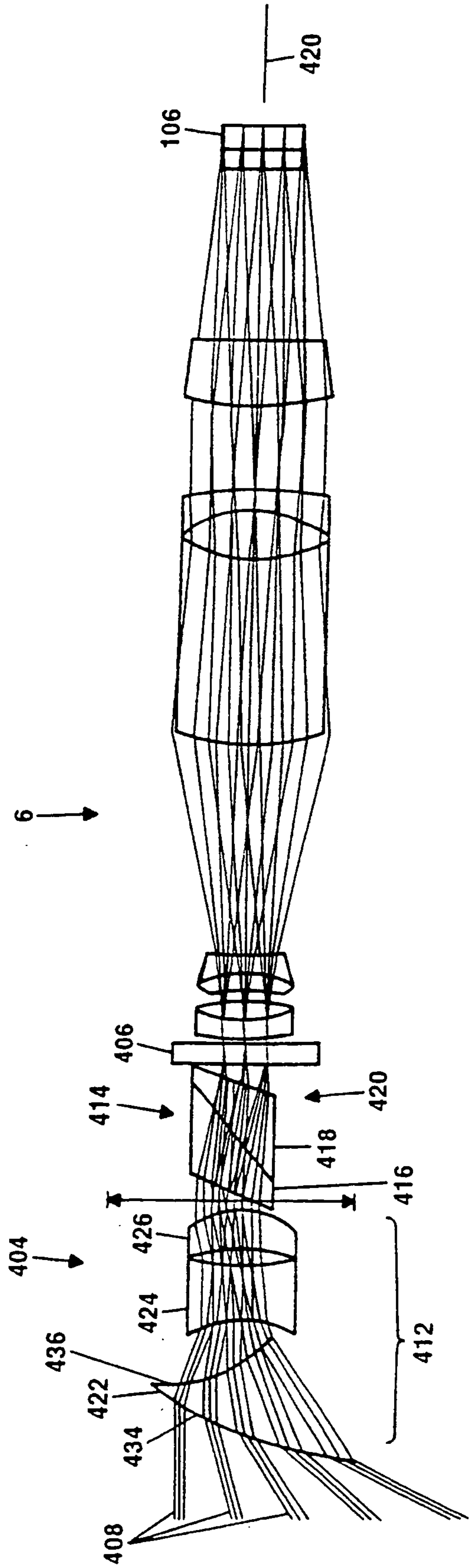
Figure 22D



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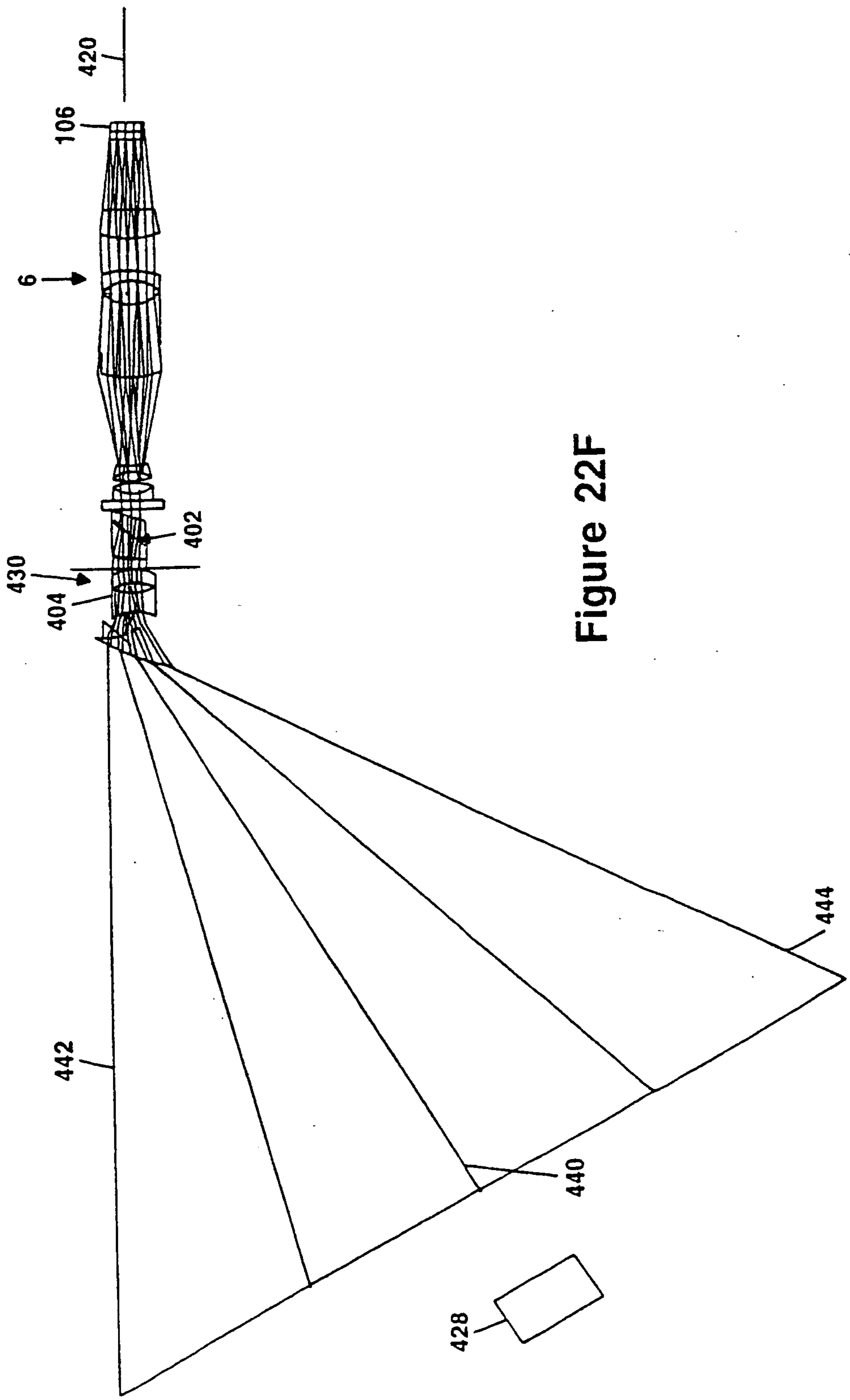

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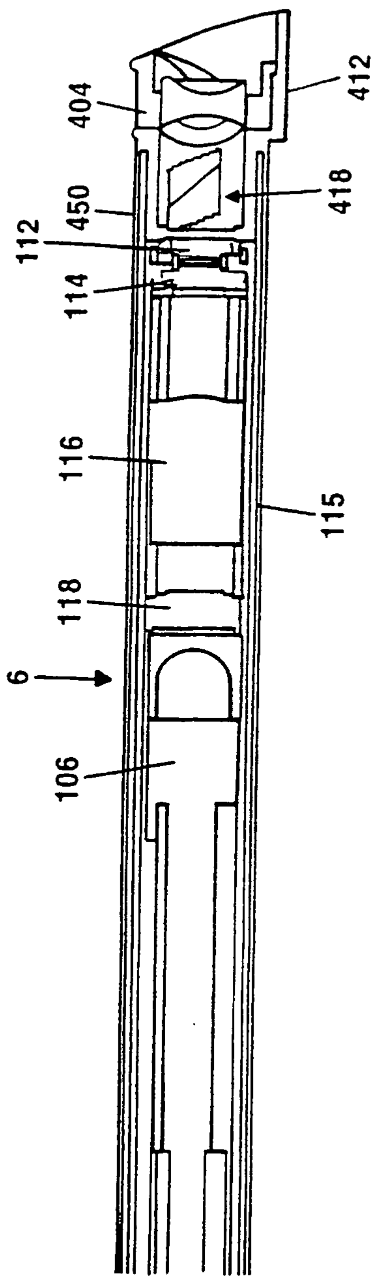
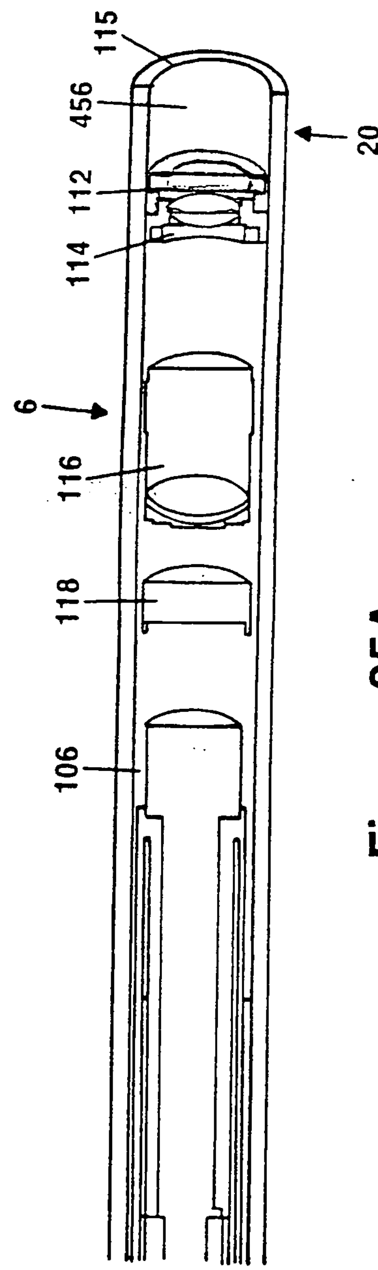


Figure 22G



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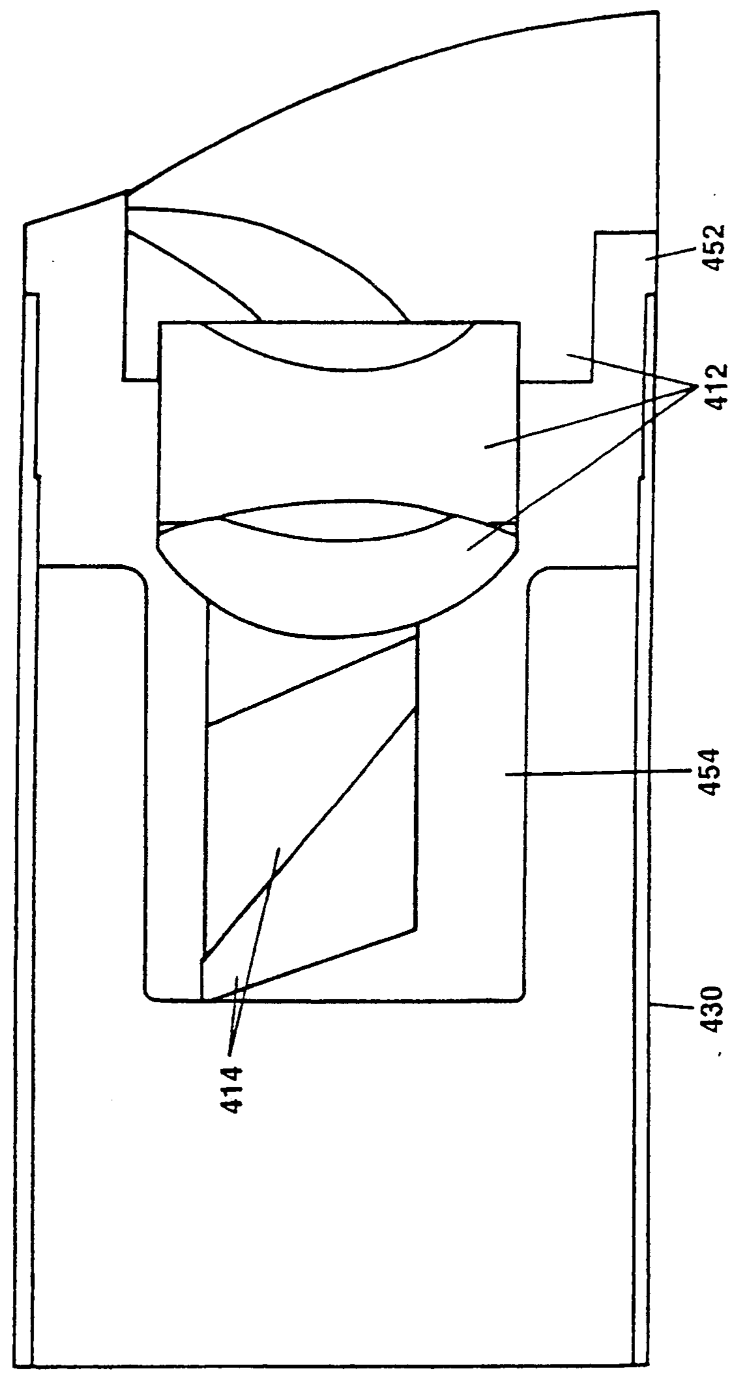

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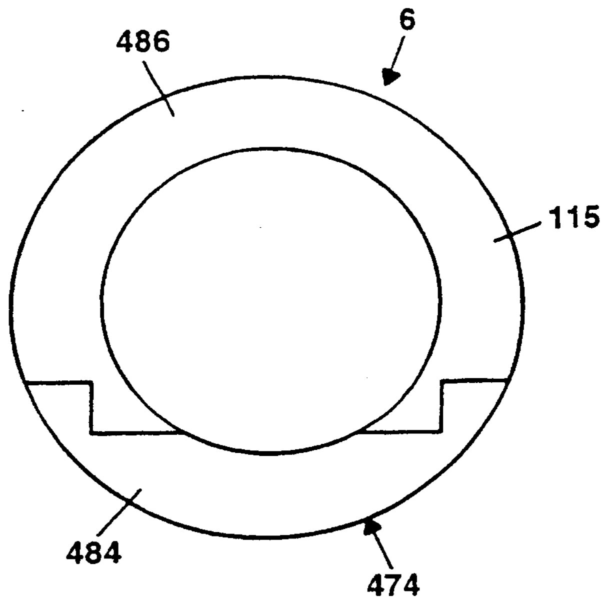


Figure 22J

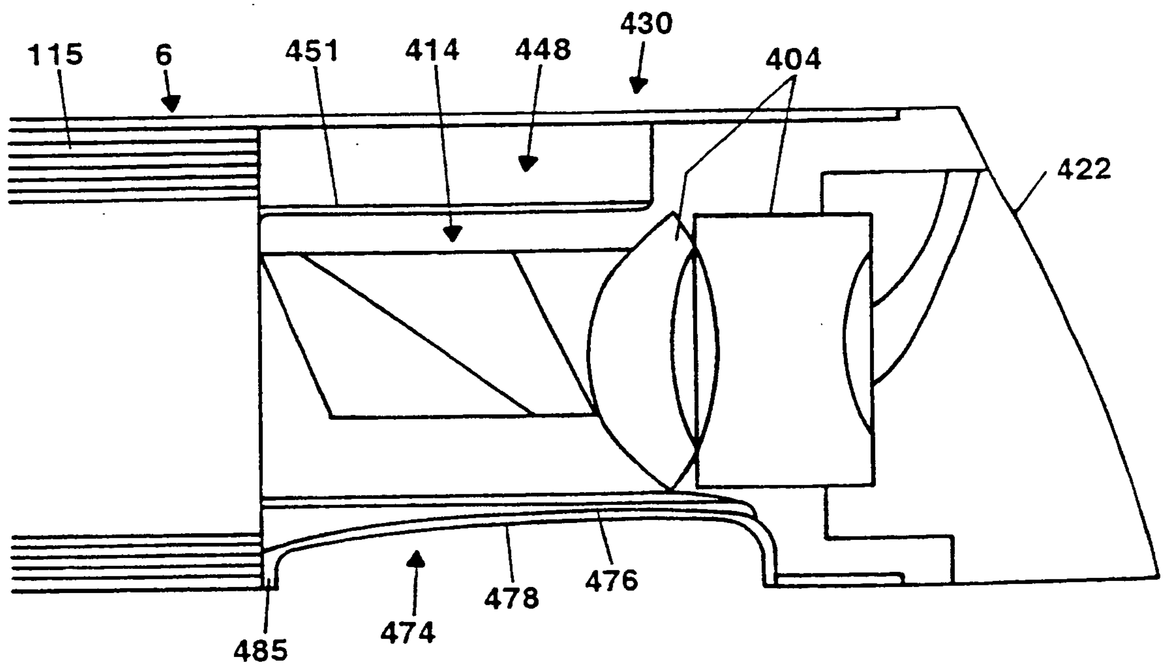
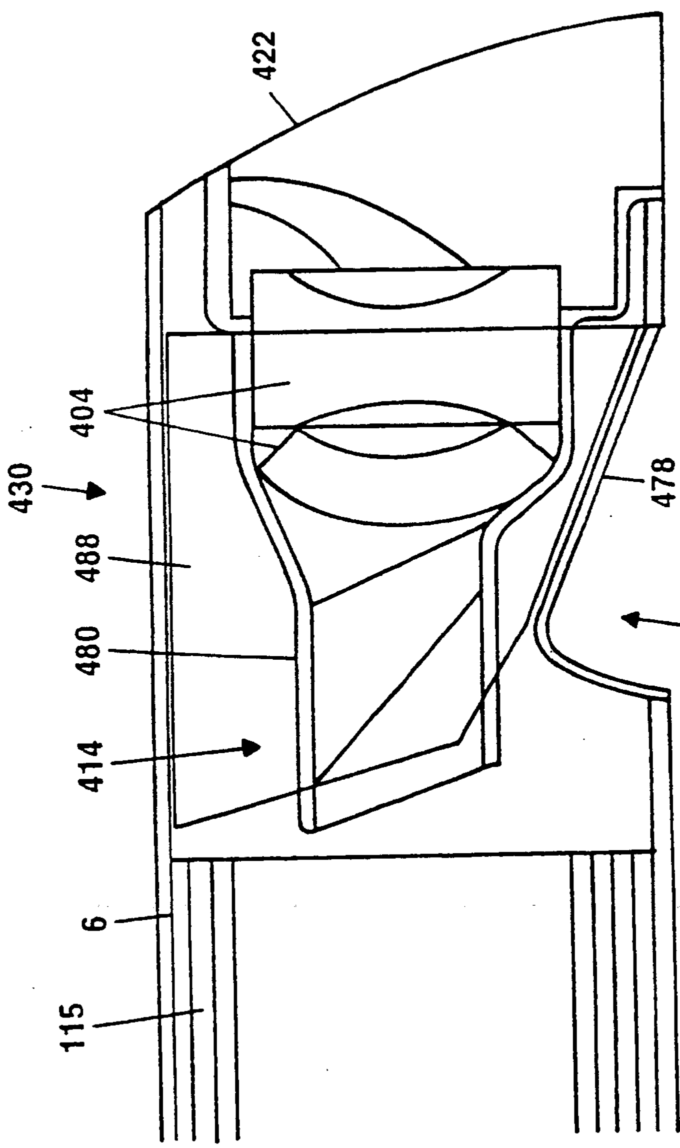


Figure 22I



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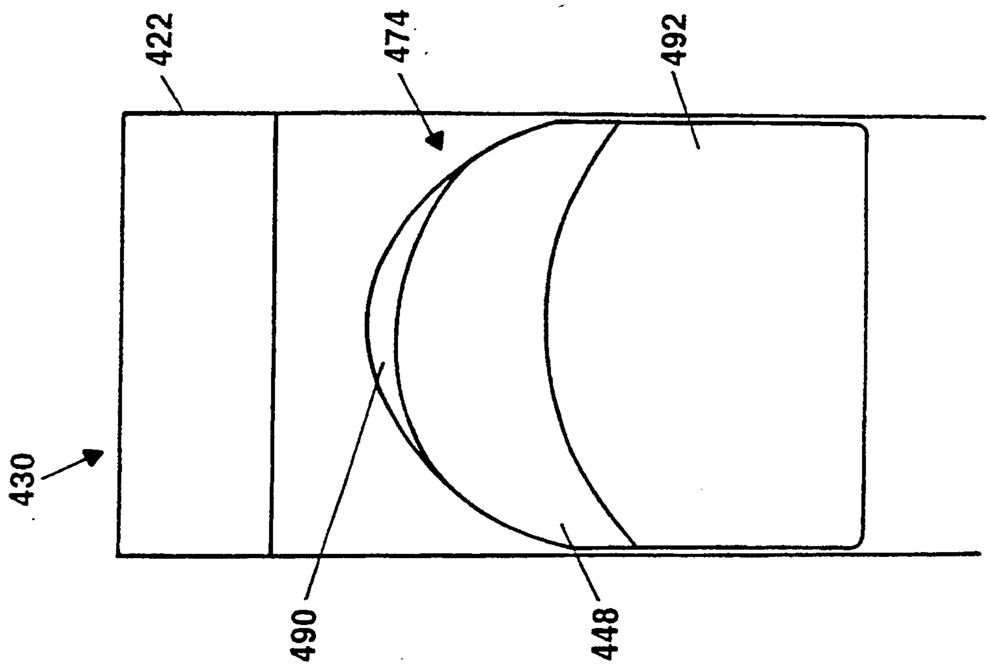
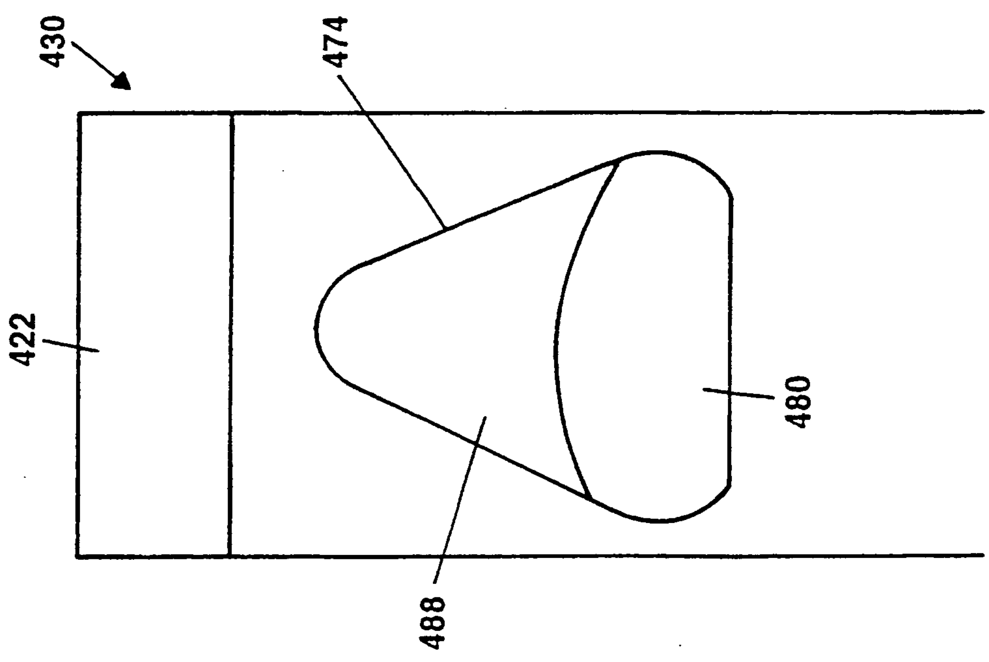


Figure 22N



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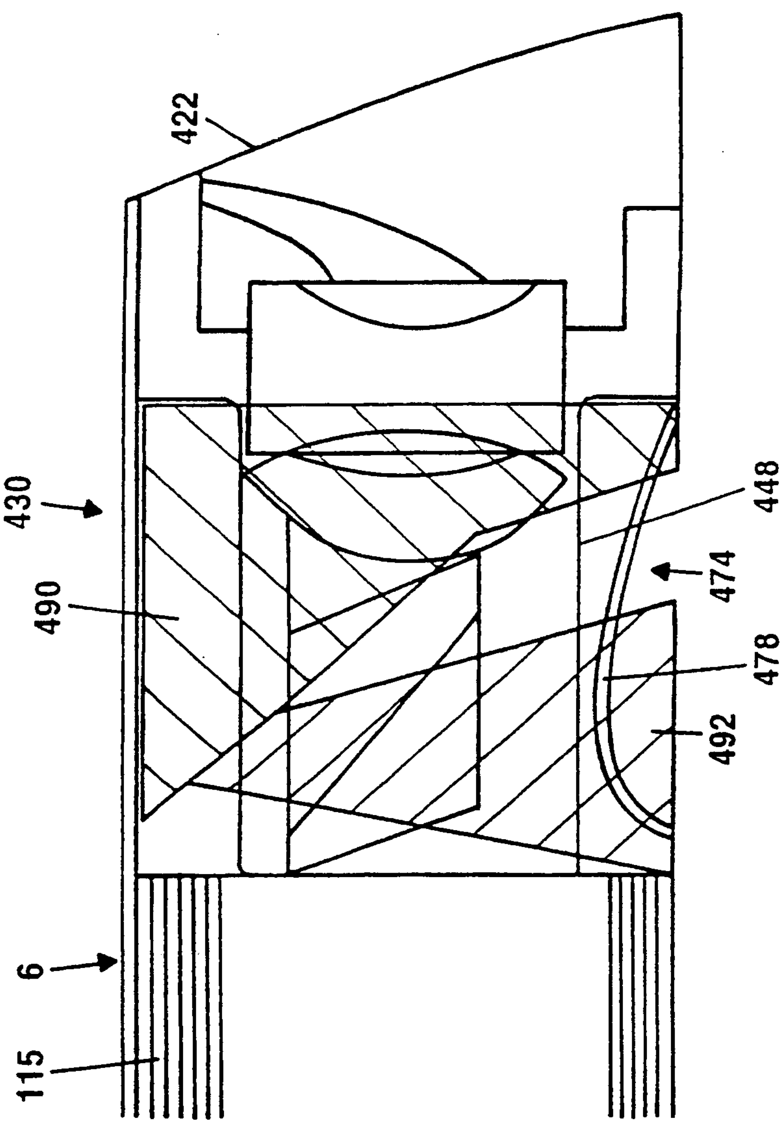

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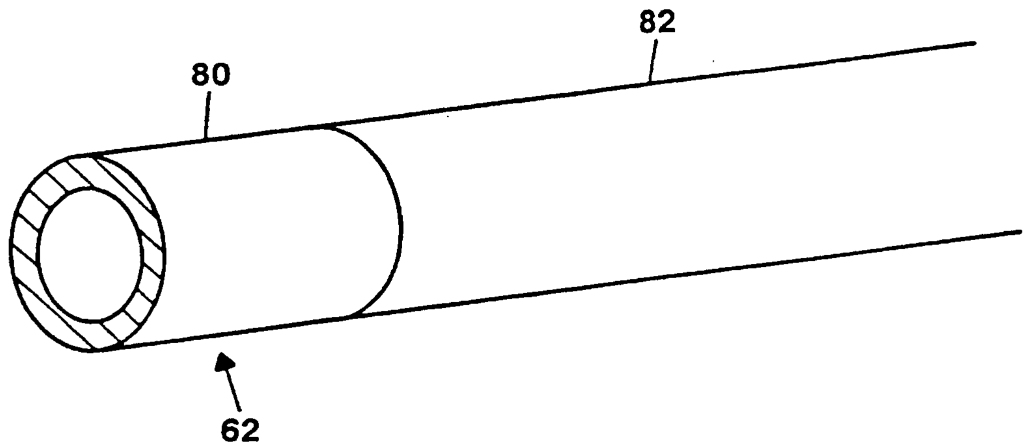

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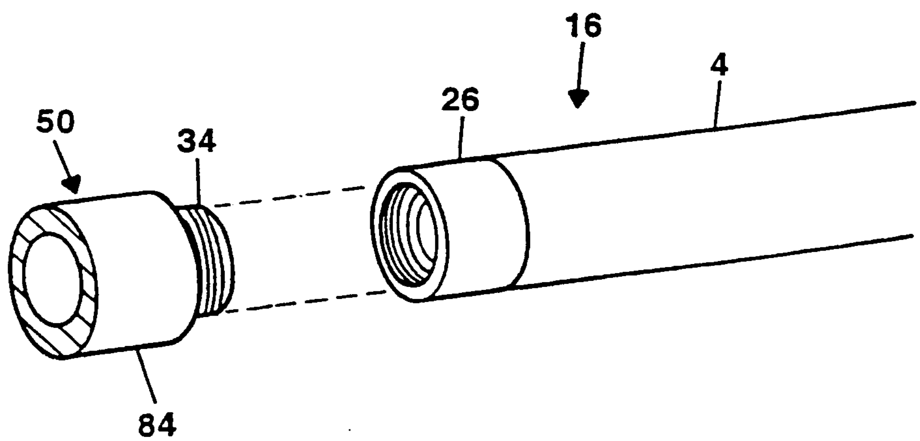

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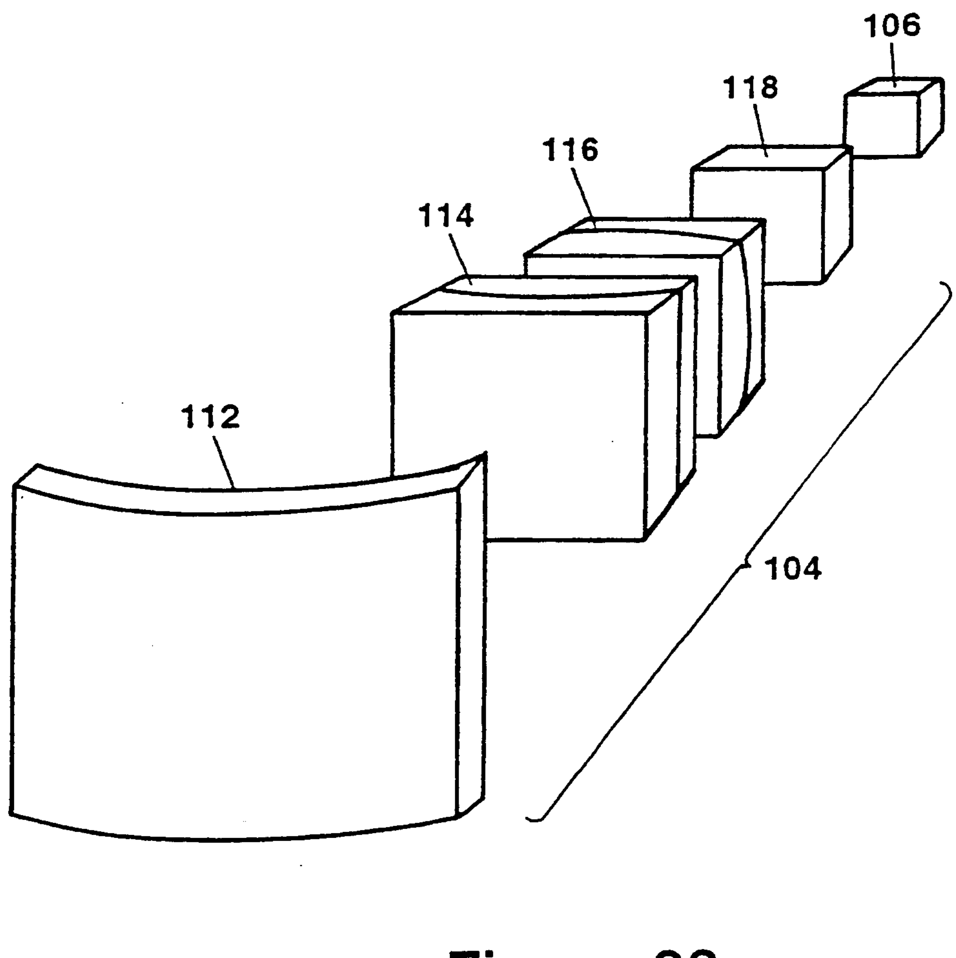

Figure 26

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/26712

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B1/04 A61B1/313 A61B1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, BIOSIS, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 00 13568 A (BALA JOHN L ;RAMIJAN PAUL (US); VISIONSCOPE INC (US)) 16 March 2000 (2000-03-16) cited in the application	1-6,8,61
A	page 7, line 13 -page 18, line 3; tables 1-12	7,9, 11-16, 18, 20-29, 37-39, 41,42, 44-46, 48, 62-70, 72-78,83

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 January 2001	23/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Weihs, J

International Application No
PCT/US 00/26712

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 690 605 A (DAVID HAMLIN ET AL) 25 November 1997 (1997-11-25) column 4, line 39 -column 6, line 16; tables 1-6	1,2,11, 18,21, 29,37, 61,72
A	US 5 486 155 A (MULLER RICHARD P ET AL) 23 January 1996 (1996-01-23) column 2, line 7 -column 3, line 54; tables 1-3	1,11,18, 21,37

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INTERNATIONAL SEARCH REPORT

Information on patent family members

ıational Application No
PCT/US 00/26712

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0013568 A	16-03-2000	AU 5818099 A	27-03-2000
US 5690605 A	25-11-1997	US 5408992 A	25-04-1995
		US RE36434 E	07-12-1999
		WO 9512344 A	11-05-1995
US 5486155 A	23-01-1996	EP 0871391 A	21-10-1998
		JP 9508555 T	02-09-1997
		WO 9602182 A	01-02-1996